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CIVIL ENGINEERING.

The Economic Construction of Girders.

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(Continued from page 25.)

GIRDERS OF GREAT SPAN.

IN our last paper we arrived at the formula for the weight of a double girder.

$$G = \frac{sk(w_2+F)}{1-sk} \quad . \quad . \quad . \quad . \quad (3)$$

and from this we drew some general conclusions as to the ultimate span.

We have now in the first place to determine the values to be assigned to F for given spans; F being the total dead weight of the portion of the complete structure required for one line of railway, exclusive of G, the weight of the bare girder.

The most anomalous part of the structure is that addition to the girders rendered necessary by their having to act in the secondary capacity of booms to the fabric, when engaged in resisting the lateral pressure of the wind; the webs in this action being represented by the strata of horizontal bracings.

Misled by the minuteness of this addition when the span is short, and a considerable width is given to an openwork structure, we spoke of it as of such moderate amount that it might generally be treated as covered by the value 3·5 taken for the factor of safety; in extreme

or peculiar cases alone a separate provision becoming necessary. Actual calculation has, however, pointed out to us that this addition becomes so very considerable as the spans increase, that, although doing so mars the simplicity of the investigation, we must make an independent allowance for it.

Notwithstanding this modification in our views, we still consider that the general factor of safety should be taken of a uniform value (3·5) for cases in which the dead weight amounts to more than a certain percentage (71·4) of the movable loading. Any apparent excess of strength that this may give for the girders of the longer spans, will probably be required to counteract the greater destructive effect of the wind, arising from the virtually increased suddenness of application, and the increased chance of the wind impulses corresponding with the oscillations of the structure.

The metal added to the girder, to resist the longitudinal stresses resulting from the lateral action of the wind, may for one double girder be represented by the letter E. This is generally, but not necessarily, incorporated with the booms of the girder. It is to be remembered that E is to be treated as part of F, not of G; G must be taken for the weight of those parts alone which are directly employed in supporting the whole weight and loading acting vertically.

The amount of E will vary so much with the nature of the structure, that any formula for it must be of limited applicability, and employed with caution; we shall endeavor, however, to arrive at one which will be suited to the general arrangement we have chosen for bringing out the comparisons, viz:—two double openwork girders placed 27 feet apart from centre to centre, prepared for the support of a double line of railway at the lower level.

The resistances to the wind will consist of that offered by the structure itself and that by the trains; estimating these by their amount per foot run of span, the latter will be constant, but the former will increase somewhat with the span the sum of these resistances, which we may denote by the letter r, and will be pretty accurately represented by this formula:

$$\left.\begin{matrix}\text{Resistance to wind in}\\ \text{tons per foot run}\end{matrix}\right\} = r = \frac{1}{100}\sqrt{s} + \frac{1}{10} \quad . \quad . \quad (4)$$

The whole side pressure on the structure will be $= sr$, therefore the sum of the stresses induced in each girder at the midspan will be—

$$= sr\,\frac{s}{8\times 27} = \frac{1}{216}\,s^2 r \quad . \quad . \quad . \quad (5)$$

This is to be distributed between the two booms of each girder, and as it may be either a tension or a compression, according to the direction of the wind, we must estimate the portion taken by the lower boom as a tension, and the portion taken by the upper boom as a compression. If the roadway be at the lower level, considerably more than the half will be brought upon the lower boom; but for our present purpose we do not need to determine the proportions in which it is dealt out to the booms, since to cover the expense of ma-

terial for joint-plates, loss by rivet holes, &c., we may take the same allowance of metal for the resistance of compressive and tensive stresses—say one inch for every four tons. The whole stress then divided by 4 gives us $s^2r \div 864$ as the sum of the additions to be made to the sections of the booms of each girder at the midspan. Now the booms being otherwise strong at the extremities, we may calculate the additions made to the sections at other parts of the span as in exact proportion to the stresses; therefore the total increase of weight in the booms will be given by this formula, E being the increase of weight in tons for the whole of the double girder—

$$E = \frac{2}{3} s \times 0{\cdot}0015 \times \frac{1}{864} s^2 r = \frac{s^3 r}{864000} \quad . \quad . \quad . \quad (6)$$

The following table will give an idea of the importance of these additions:—

TABLE I.

Span in feet.	r, in tons.	Increase of section at the midspan in sq. inches.	Increase of weight or E in tons.
100	·200	2·31	0·23
200	·241	11·11	2·22
300	·273	28·11	8·40
400	·300	55·55	22·22
500	·324	93·72	46·86
600	·345	143·7	86·22
700	·365	207·0	144·90
800	·383	283·6	226·88

The Horizontal and Transverse Bracings.—We have now to calculate the weight of these. The horizontal bracings may be arranged in two or more strata. When the number is more than two, that is when, besides the bracing at the top and bottom of the girder, one or more bracings at intermediate heights are introduced, part of the metal E treated of as above as generally incorporated with the booms must be detached therefrom, and affixed where the horizontal bracings join the web. The existence of intermediate strata will strengthen the struts of the web, but may occasion the consumption of some more material in the horizontal bracings themselves; which, however, will be compensated by a saving in the transverse bracings.

In the principal stratum of horizontal bracing, or that at the level of the roadway, some saving may be effected by making use of the transverse girders as struts.

In very many cases a considerable saving of material will arise from making the parts of a horizontal bracing *double-acting*, so that every part will be of use, on whichever side the wind may blow. This saving will become more significant the greater the stress to be conveyed, since the efficiency of the parts to act as struts becomes thereby greatly augmented. The saving on this account in large structures (the length of the parts being nearly constant) is so important that it may be looked upon as fully counterbalancing the increase in the value of r, as exhibited in Table I. We consequently find that a very simple formula will express with sufficient accuracy the weight

of the horizontal and transverse bracings, taken together and estimated very liberally.

$$\left.\begin{array}{l}\text{Weight of horizontal and transverse}\\ \text{bracings for each line of railway,}\end{array}\right\} = s^2 + 8000 \quad . \quad . \quad . \quad (7)$$

The results for various spans will be found in col. 3 of Table II.

The Transverse Girders of the Roadway Platform.—If these are made pretty deep, and placed, say 6 feet apart, we may take them with fastenings complete at 1·8 ton each; this is equivalent to 0·15 ton per foot run for each line of railway.

The Planking, Longitudinal Bearers, &c., of Timber.—We may take the united sectional area of these at 12 feet for the whole bridge, which with an allowance for fastenings, and a protecting coating of sand, &c., may be estimated as amounting to 0·15 ton per foot run for half the width of the bridge, or for one line of railway. The total roadway platform, &c., which constitutes the constant portion of F, may then be estimated as follows, for one line of railway, or per double girder.

Transverse girders	0·15 per foot run.
Planking, balks, &c., ...	0·15 "
Permanent way	0·06 "
Handrail, ...	0·01 "
Total, ...	0·37

Weight of roadway platform, permanent way, including safety rails, &c., and all other dead weight excepting G, E, and the horizontal and transverse bracings,

$$= s \times 0{\cdot}37 \quad . \quad . \quad . \quad . \quad (8)$$

And therefore

$$F = E + \frac{s^2}{8000} + 0{\cdot}37s \quad . \quad . \quad . \quad . \quad (9)$$

The following table exhibits some of the values in tons of F and its components.

TABLE II.

Span.	E.		H and T bracings.		Platform, &c.		F.
100	0·23	+	1·25	+	37	=	38·48
200	2·22	+	5·00	+	74	=	81·22
300	8·40	+	11·25	+	111	=	130·65
400	22·22	+	20·00	+	148	=	190·22
500	46·86	+	31·25	+	185	=	263·11
600	86·22	+	45·00	+	222	=	353·22
700	144·90	+	61·25	+	259	=	465·15
800	226·88	+	80·00	+	296	=	602·88

We now proceed to ascertain the values of k for various structures, treated with different values of the factor of safety.

Formula (2) gives us $k = \frac{G}{WS}$, wherein W represents the whole load supported, and supposed to be uniformly distributed over the span.

Let us first take, as perhaps the simplest possible example, a solid rectangular bar of wrought iron; and let us assume that a bar one inch square placed on supports one foot asunder, becomes destroyed, for all practical purposes, by a central load equal to one ton, or two tons

spread uniformly over its length. Then calculating our elements for such a bar, we have G=·0015 tons, W=2·0015 tons, S=1. And therefore

$$k_1 = \frac{\cdot 0015}{2\cdot 0015} = \cdot 000749$$

And $k_{3\cdot5} = 3\frac{1}{2}k_1 = \cdot 002622$.

The ultimate span to which such a bar could be extended without breaking down under its own weight, supposing no lateral disturbing cause, such as the wind, to exist, would be =1÷·000749=1335 feet. And the utmost span to which, under similar circumstances, such a bar could be extended, so that the factor of safety should not descend below 3·5, would be

=1÷·002622=381 feet.

If the effects of the wind were introduced, these ultimate spans would undergo reductions according to the narrowness of the bars.

In the above example the span is twelve times the depth. To show, in a simple manner, the influence of the ratio of the depth to the span upon the value of k, let us take the rectangular bar of double the above depth. For a bar of 2 inches deep, say 2 inches wide, and 1 foot span, we have G=·006, w or the distributed breaking weight = 2 tons × breadth × square of depth = 16 tons, S=1. Therefore

$$k_1 = \frac{\cdot 006}{16\cdot 006} = \cdot 000375, \text{ and ult. span} = 2667.$$

This latter bar has therefore double the economic merit of the other.

As another example let us take the Conway tube. The calculation of the value of k for this is rendered a great deal more complicated by having to consider the amount E, of the material abstracted to resist the wind-induced stresses. We shall, in the first instance, assume that no wind will act upon it. Taking then W_1 or the total dead weight=1112 tons (this is the same as in our calculation at page 194*, but must be an under-estimate), and W_2=400 tons, we found T to be equal to 7·18 tons, and C=5·05 tons; so that the factor of safety, as measured from the tension, is=19÷7·18=2·65 nearly. G may here be taken equal to 1050 tons, no value for E, but only keelsons, &c., which are not directly concerned in the girder action, having to be deducted. We have then F=62, W=1512. And therefore

$$k_{2\cdot65} = \frac{1050}{1512\times 400} = \cdot 001736,$$

k_1=·000655, and $k_{3\cdot5}$=·002293.

And the ultimate spans (the proportion of depth to span=1:18·35, page 234, being maintained) would be as follows:—

With factor of safety=1,		Ultimate span=1527 feet.	
"	"	2·65,	" 576
"	"	3·5,	" 436·2

We see then that even were no such antagonistic force as the wind to exist, it would be almost impossible to construct the Conway tube

* Journ. Frankl. Inst. vol. xl.v. p. 319.

with a sufficiently high factor of safety, the economic merit of the structure being so low; with a value of $k_{2\cdot5} = \cdot0022925$, S=400, $W_2=400$, and F=62, we find by formula (3) the weight of G alone to be $=\frac{\cdot00917}{\cdot00083} \times 462 = 5152\frac{1}{2}$ tons.

We offer the following as an approximate calculation when the effect of the wind is to be allowed for. At page 196 it was shown that the wind, estimated at 30 lbs. per superficial foot, causes at the edges of the booms a stress of tension T equal to 1·875 tons, or eT=1·4 tons. Now here occurs the principal difficulty in the calculation; we require to fix upon a certain factor in computing the amount of E to be abstracted to resist the wind-induced stresses, but this factor should evidently bear some relation to the factor applied to the stresses produced by the vertical pressure of the total weight supported. If we demand for E 1 inch of sectional area for every 4 tons of stress, although this is reasonable in itself, it would be out of all proportion to the stress to which the remaining material would be subjected by the vertical pressures; this great discrepancy being caused by the excessive weakness of the structure. We shall, therefore, give the results for different ratios of section to stress.

1st, When E is calculated at the rate of 4 tons per inch (that is, for C and eT, but not to cover joint-plates), the wind stresses appropriate the $\frac{1\cdot4}{4}$ part of the whole section at the midspan, or 503 inches; and the weight of the iron thus taken from G will be $=\frac{2}{3} 503 \times 400 \times \cdot0015$ ton $=201$ tons, to which we may add 49 tons for the proportion of joint-plates; this makes E=250 tons; F will therefore be=62 +250=312 tons, and G=1050—250=800 tons; $W_2=400$, and $W_1=1112$, as before. And to obtain the value of the factor of safety, since the metal left for girder action is only $=\left(1-\frac{1\cdot4}{4}\right)=\frac{2\cdot6}{4}$ of that which gave T=7·18 tons, the value of T will now be $=7\cdot18 \div \frac{2\cdot6}{4} = 11\cdot05$. The excess of T here given over the value 9·053, obtained at page 196, arises from the discrepancy above referred to. From these data we readily deduce the following factor of safety $=\frac{19}{11\cdot05}=1\cdot72$.

$$k_{1\cdot72} = \frac{800}{1512\times400} = \cdot001323$$
$$k_1 = \cdot000769$$
$$k_{3\cdot5} = \cdot002692$$

The ultimate span with this latter value (which corresponds with the proper factors of safety) would be only $=1+\cdot002692=371\frac{1}{2}$ feet. Showing that it would be altogether impossible to construct a bridge on the system of the Conway tube—having an effective depth like it of less than $\frac{1}{18}$th of the span, which with a movable loading at the rate of

1 ton per foot of span, and subjected to a windstorm equivalent to 30 lbs. on the superficial foot, would still have a factor of safety equal to 3·5—*unless the span were under* 371½ *feet.*

2d, When E is calculated at the rate of 6 tons per inch, the part of the midspan section appropriated amounts to 335 inches; so that, T being now equal to $7{\cdot}18+\frac{6-1{\cdot}4}{6}=9{\cdot}365$, the factor of safety against gravitation will have a value equal to $19\div 9{\cdot}365=2{\cdot}03$ nearly; and E, taken with the same proportion for joint-plates as before, amounts to 167 tons; therefore G=883 tons, and

$$k_{2\cdot03}=\frac{883}{1512\times 400}=\cdot00146.$$

This is a very near approximation to the true state of the Conway as calculated at page 196: we there have the factor of safety=19÷9·053=2·1 nearly. The corresponding value of k will be given with sufficient accuracy from the above—thus

$$k_{2\cdot1}=\frac{2\cdot1}{2\cdot03}\times\cdot00146=\cdot00151,\text{ say}=\cdot0015.$$

From this we obtain approximately the ultimate span for the Conway tubes under their present condition of stress, &c.

$$=1\div\cdot0015=667\text{ feet.}$$

We might proceed to find still more exactly the value of $k_{2\cdot1}$ for the Conway, but it is not of sufficient consequence, since such would not be applicable to other spans, without a separate estimate of the value of F for each.

We shall now endeavor to arrive at correct values of k for open-work girders, such as described at pages 150, 164, &c., having a depth equal to $\frac{1}{8}$th of the span.

When the span is short, the factor E may be neglected; and therefore G becomes identical with the weight of the girder. Consequently we have G=tabular number $\times\left(\frac{s}{8}\right)^2$

For these girders, w_1 is=½s tons, w_2=s tons, w=1½s tons, and the factor of safety calculated from the most severely stressed parts is as nearly as may be=4. Therefore

$$k_4=\frac{G}{Ws}=\text{Tab. number}\times\left(\frac{s}{8}\right)^2\div 1\tfrac{1}{2}s^2=\frac{1}{96}\text{ of Tab. number.}$$

$$k_1=\frac{1}{384}\text{ Tab. number, and }k_{3\cdot5}=\frac{1}{109\cdot7}\text{ Tab. number.}$$

For the 1st and 9th forms (page 164) with the load at the lower level, the tabular numbers are respectively ·1078 and 1·010. Consequently the values of k are as follow:—

First form	$k_1=\cdot000281$	$k_{3\cdot5}=\cdot000983$
Ninth form	$k_1=\cdot000263$	$k_{1\cdot5}=\cdot000921$

It has here been assumed that allowances of metal in proportion to stress are the same for any span. The correctness of this will be apparent, when we consider that W, the total load supported, increases much more rapidly than the span; and if exactly the same pattern

of girder were retained, would warrant an increase in the value of c for the bracing struts. As, however, it is necessary to provide a greater number of points of support to the roadway in long spans, it becomes necessary either to supply suspension rods, or to cut up the simple bracing into one or more series, the result being that, as stated in Prop. III., page 233, so long as the general character of the structure is retained, the weight G varies as $S \times W$. Of course we do not mean that this holds good with perfect exactness, but it is sufficiently accurate for the purposes of a general view of the subject. The value of k may then be obtained from any size of bridge, since it only expresses inversely the economic merit of any particular form of construction. As some readers, from not having sufficiently studied the previous articles, may not see very clearly how the above values of k have been obtained, we here offer a general approximate estimate of the weight of a double girder.

Estimate of the Weight of an Openwork Girder, having a Depth equal to $\frac{1}{8}$th of the Span.—When the loading is assumed to be concentrated at the level of the upper or lower boom, the stresses produced in the corresponding bays of the two booms do not agree; thus, in Table X., page 149, the stresses in the central bays of the upper boom amount to only 2·25 units, while in the corresponding bays of the lower boom they amount to 24. Now in all such cases it is the greater stress which is given by the common formula, viz.: stress in booms$=WS \div 8D$; and the more numerous the series of bracings and the greater the number of triangles in each series, the more nearly will the stresses in the two booms correspond with one another; and it may be remarked that the stresses at the actual centre of the span are both really the same as given by the formula. This is a point of some importance when, as in Table XI., the lower boom has its central bay less strained than its central joint; in such a case the joint-plates must be of extra thickness compared with the plates. Let us assume, then, that the formula gives the central stresses with sufficient accuracy, the error will be on the safe side, and will most affect the shorter spans. The central sectional areas will be equal to $WS \div 8D \cdot C$ for the upper, and $WS \div E \cdot eT$ for the lower boom. Now, if we could vary the sections in proportion to the stresses, the average sectional areas would be two-thirds of these central ones. We can, with some approach to accuracy, apportion the sections to the stresses to a considerable distance on either side of the midspan, but there are various practical objections to reducing the sections towards the extremities below a certain percentage of the central ones—we may take these limits at about 65 per cent. for the upper, and 35 per cent. for the lower boom. The resulting average sections are about 75 per cent. for the former, and 70 per cent. for the latter, and the amounts to be added for joints and rivets about 15 and 20 per cent. respectively; the top being understood to be built up of plates and angle-irons, and the bottom of bars without longitudinal lines of riveting. The weights of the booms will therefore be as follow, C and eT being taken equal to $3\frac{1}{4}$ and 4 tons respectively:—

Weight of upper boom,

$$=\frac{ws}{8D3\frac{1}{4}}\times\cdot75s\times1\cdot15\times\cdot0015 \text{ ton}=\frac{ws^2}{D}\cdot00004975 \quad . \quad . \quad . \quad (10)$$

Weight of lower boom,

$$=\frac{ws}{8D4}\times\cdot70s\times1\cdot20\times\cdot0015 \text{ ton}=\frac{ws^2}{D}\cdot0000394 \quad . \quad . \quad . \quad . \quad (11)$$

When $D=\frac{1}{8}s$, these become respectively

$$ws\times\cdot000398 \text{ and } ws\times\cdot000315.$$

The Bracing.—When all the loading w is assumed to be transmitted through the bracing (this rather exaggerates the effect of the loading), then the braces at one end of the structure are altogether conveying a stress$=\frac{1}{2}w \sec\theta$, and the length of each series of braces is$=s \sec\phi$. We may assume one-half of the braces to be struts, and the other ties; and if all the struts were retained with the same sectional area throughout the span, their total weight would be$=\frac{1}{4}ws \sec\theta \sec\varphi\times\cdot0015\div c$, and similarly the weight of the ties would be equal to the same with e_T substituted for c; and when $\theta=45°$ these weights would become—

$$\text{Struts}=\frac{ws}{c}\times\cdot00075 \qquad \text{Ties}=\frac{ws}{e_T}\times\cdot00075.$$

Now if all the loading were fixed or constant, and the sections everywhere made in proportion to the stresses, the average sections would be equal to half of the sections at the extremities of the girder, and consequently the weights equal to only half of the above. Practically, we may take the average section of the struts at 70, and that of the ties at 60 per cent. of the strongest, and allow for rivets and extra lengths 10 per cent. for the former, and 5 for the latter; so that, taking $c=2\frac{1}{2}$ and $e_T=3\frac{1}{2}$, we have

Weight of bracing struts,

$$=7\cdot\frac{ws}{2\cdot5}\times\cdot00075\times1\cdot10=ws\times\cdot000231 \text{ ton} \quad . \quad . \quad . \quad . \quad (12)$$

Weight of bracing ties,

$$=\cdot6\frac{ws}{3\cdot5}\times\cdot00075\times1\cdot05=ws\times\cdot000135 \text{ ton} \quad . \quad . \quad . \quad . \quad (13)$$

Total bracing . . . $=ws\times\cdot000366$ ton.

And for the total weight of the girder we therefore have

Upper boom	$=ws\times\cdot000398$
Lower boom	$=ws\times\cdot000315$
Bracing	$=ws\times\cdot000366$
Total of girder taken =s long, and without end pillars, . . .	$=ws\times\cdot001079=G$

Now since $k=\frac{G}{ws}$, we simply have $k_4=\cdot00108$, $k_1=\cdot00027$, and $k_{3\cdot5}=\cdot000945$. Which results are sufficiently confirmatory of those obtained from the tabular numbers.

Let us now inquire what reduction can be made upon the values of k, by employing superior materials, greater depth, &c. From the foregoing investigation we find the relative weights of struts to ties as follows:—

Struts of bracing	= ·000231	Ties of bracing	=·000135
Top of girder	= ·000598	Bottom of girder	=·000315
	·000629		·000450

Now, if we adopt steel for the ties, we may reduce the sections to one-half; and by selecting a suitable variety of hard wrought iron for the struts, we may reduce their sections by, say 15 per cent. The changes are as follow:—

	Proportional Weight of Girder when ordinary wrought iron is used.		Proportional Weight of Girder when steel is used for the ties, and selected wrought iron for the struts.
Struts	629	Struts	535
Ties	450	Ties	225
	1079		760

A corresponding reduction will take place in the values of k. Assuming the somewhat exaggerated value of ·001 for $k_{3\cdot5}$ in ordinary wrought iron girders, with a depth equal to $\frac{1}{8}$th of the span, we have the following changes:

Ordinary wrought iron.	Steel and selected iron.
$k_{3\cdot5} = ·001000$	$k_{3\cdot5} = ·000705$
$k_{1\cdot0} = ·000286$	$k_{1\cdot0} = ·000202$
$k_{3\cdot0} = ·000857$	$k_{3\cdot0} = ·000604$
$k_{2\cdot1} = ·000600$	$k_{2\cdot1} = .000423$

By increasing the depth of the structure, we may obtain still lower values of k: there are, however, objections to carrying this source of economy too far.

We have seen that the weight of the booms, compared with that of the bracing, is nearly as 2 to 1; if we increase the depth from $\frac{1}{8}$th to $\frac{1}{6}$th of the span, we reduce the stresses in the booms in the proportion of 2 to $1\frac{1}{2}$, while the weight of the bracing, if we can retain the same values of C, is not affected; the whole weight of the girder is therefore reduced in the proportion of 3 to $2\frac{1}{2}$, assuming the values of C and eT to remain unaltered; this would give us, when steel and selected wrought iron are employed, the values of k as follows: k_1= ·00017, $k_{2\cdot1}$=·00035, k_3 =·00050, and $k_{3\cdot5}$=·00059.

For short spans it might be far from economical to make use of expensive steel and selected iron, but when we have to deal with very long spans, the ultimate saving of expense from their adoption will be very great indeed: this will be evident from an inspection of the values of G in Table IV.

When, on the other hand, we diminish the depth of the girder, we increase in very nearly the same proportion the weight of the booms, without affecting very materially that of the bracing. Taking, for girders having a depth equal to $\frac{1}{8}$th of the span, $k_{3\cdot5}$=·001000 as a standard, and estimating in this manner the weights for other proportions, we get the following values of k for openwork girders of good ordinary wrought iron work.

TABLE III.

Ratio of span to depth.	k_1	$k_{2\cdot1}$	$k_{3\cdot0}$	$k_{3\cdot5}$
6	·000238	·000500	·000714	·000833
8	·000286	·000600	·000857	·001000
10	.000334	·000700	·001000	·001167
12	·000381	·000800	·001143	·001333
14	·000429	·000900	·001286	·001500
16	·000476	·001000	·001428	·001667
18	·000524	·001100	·001571	·001834
20	·000571	·001200	·001714	·002000

From defects of this method of deriving the weights, the values in the table for the shallower girders must be considered somewhat exaggerated.

We may now offer an example of the complete calculation of the weight of G, of the whole of one double girder, and of the half of the complete viaduct of two lines of railway. Let S be taken equal to 400 feet as in the Conway tube, then W_2=400 tons, and by Table II., E=22 tons, and F=190 tons; therefore, when $k_{3\cdot5}$ is taken=·001, we have

$$G=\frac{Sk}{1-Sk}(W_2+F)=\frac{\cdot4}{\cdot6}\,590=393 \text{ tons.}$$

Complete girder or G+E=415 tons.

Share of complete structure due to one line of railway, including timber, &c. . . . . } =G+F=583 tons.

This is a very satisfactory result to contrast with the 1112 tons of the Conway, when we bear in mind that the factors of safety are respectively 3·5 and 2·1.

A fairer comparison will be given by adopting a factor of safety equal to that of the Conway, viz: 2·1; although this will still be unjust towards the deep openwork structure, in so far as the value of F is unduly high when such a factor is employed.

With a factor=2·1, and ordinary good iron, we have seen that $k_{2\cdot1}$=·0006; so that $G=\frac{\cdot24}{\cdot76}\,590=186$ tons only, showing the great influence which the value of k has upon the weight of very long girders. G+E=208 tons, and G+F=376 tons instead of 1112 tons. By the employment of steel and selected iron, and a depth equal to $\frac{1}{8}$th of the span, we have shown that $k_{2\cdot1}$ might be reduced to about ·00035. This gives us

$$G=\frac{\cdot14}{\cdot86}\,590=95 \text{ tons, G+E=117, and G+F=285 tons.}$$

The adoption of such a structure as this, though showing the same general factor of safety as the Conway tube, would not of course be advisable. Let us see what is the lightest that might be recommended. Many engineers believe that a factor=3 gives ample surplus strength in large structures. Now the value of k_3, when steel and selected iron are used, along with a depth equal to $\frac{1}{8}$th of the span, is =·000604. Consequently, for a span of 400 feet, we have

$$G = \frac{400 \times \cdot 000604}{1 - 400 \times \cdot 000604}(W_2 + F) = \frac{\cdot 2416}{\cdot 7584}\,590 = 188 \text{ tons.}$$

Complete double girder . . = G + E = 210 tons.

Half of complete structure fitted for two lines of railway including timber, permanent way, &c. } = G + F = 378 tons.

With ordinary iron $k_3 = \cdot 000857$, and hence G = 308, or 120 tons more than when superior materials are employed.

It then appears that, by employing an openwork structure having a depth equal to $\frac{1}{8}$th of the span, the Conway tube, with a factor of safety equal to only 2·1, and weighing more than 1112 tons, could have been replaced by any of the following:—

1. A structure composed wholly of wrought iron except the planking and other timbers of the roadway, which including timber, permanent way, &c., would, with a factor of safety also equal to 2·1, have weighed only 376 tons.

2. A structure as above, but with a factor of safety equal to 3, which would have weighed only 498 tons.

3. A structure as above, but with a factor of safety equal to 3·5, which would have weighed only 583 tons.

4. A structure composed of steel and selected iron for the girders, and ordinary iron and timber for the other parts, which with a factor = 2·1 would have weighed only 310 tons.

5. A structure as above, but with a factor equal to 3, which would have weighed only 378 tons; or

6. A structure as above, but with a general factor of safety equal to 3·5, which would have weighed only 422 tons.

These facts have, to some considerable extent, been long known to a few; yet the public has been led to regard such structures as the Conway, Britannia and Victoria Bridges with pride. Another generation may, with more reason, classify them—at least in so far as the *superstructures* are concerned—as perhaps the most expensive engineering blunders of the century.

TABLE IV.—*Containing the Values of* G *in Tons, corresponding with given Values of k and* s, *and with the Values of* F *given in Table II.*

Span in feet=	100	200	300	400	500	600	700	800	
Value in tons of $W_2 + F$ being whole load supported less G=	138	281	431	590	763	953	1165	1403	Ultimate spans in feet.
Values of k	Values of G.								
·0005	7·3	31·2	79·6	147·5	254	408	627	935	2000
·0006	8·8	38·3	94·6	186	327	536	843	1295	1667
·0007	10·4	41·0	115	230	411	690	1119	1786	1429
·0008	12·0	53·5	136	278	509	880	1483	2294	1250
·0009	13·6	61·7	159	332	624	1119	1930	3608	1111
·0010	15 3	70·3	185	393	763	1430	2718	5612	1000
·0012	18 8	88·7	242	545	1144	2451	....	....	833
·0015	24·4	120·	353	885	2289	8577	....	....	667
·0020	34·5	187·	647	2360	∞	....	....	....	500

In the case of the Victoria Bridge, however, all must admire the boldness, skill, and success attendant upon the founding and rearing of its piers of masonry in the rushing stream of the St. Lawrence. Having obtained the values of G, as in Table IV., we can readily ascertain the weight of the complete girder, or that of half of the complete structure for two lines of railway, by simply adding the values of E or F contained in Table II. We give the following examples, in which $k = \cdot 001$.

TABLE V.

Span in feet . . . =	100	200	300	400	500	600	700	800
G in tons	15·3	70·3	185	393	763	1430	2718	5612
Girder complete, or G+E	15·5	72 5	190	415	810	1516	2863	5839
Bridge complete per line, including timber, &c., =G+F . . . . =	53·8	151·5	316	583	1026	1783	3183	6215
Total load supported by the girder = w = w_2 +F+G . . . . —	154	252	616	983	1526	2383	3883	7015

Edinburgh. R. H. B.

(To be Continued.)

Lambeth New Suspension Bridge.

From the London Artizan, December, 1862.

Lambeth new Suspension Bridge, has a total length over all of 1040 feet, and a length between the abutments on the shore at either side of 828 feet. Its extreme width is 32 feet, which is divided into 20 feet for roadway, and six feet for each of the footpaths, and its total height above high-water mark is 21 feet clear. The rise or curve of the structure is one in 22 feet on the bridge itself, and one in 20 feet on the approaches. For such a steep rise the bridge itself should have given a greater headway than 21 feet, but this would have involved heavy outlay in raising the approaches at either end, and, of course, could not be attempted in a structure the total cost of all connected with which, even to painting and roads to it, was not to exceed £40,000. The suspension ropes are taken over four pairs of towers, two of which at either end rest on the abutments of solid masonry, and two are upon circular piers in the bed of the river. Over these towers the suspension ropes are carried, sustaining the bridge beneath in three spans of 280 feet in length each. These towers, though they look exceedingly light, are reported to be as many as seven times stronger than any strain they can ever be called upon to bear, even supposing the road and footway of the structure to be densely packed with a crowd of people. Each tower is of boiler plate ¼-inch thick, strengthened with 2½ ins. angle iron, and built upon the cellular principle adopted in the Britannia Bridge, and in the double sides of the Great Eastern. The sectional area of these towers gives 120 square inches of iron, and the utmost weight which can come upon them, when

the bridge is fully weighted to its load strain is only 2½ tons per inch, —just half the strain which the Britannia Bridge, on the same principle, has always to carry, and, we believe, about one-third of the strain upon the great Victoria Bridge at Montreal. At the abutments, as we have said, two of these towers rest on masonry of the most solid description. On the river piers they are fixed on circular cast iron cylinders, which are taken down 18 feet below the bed of the river and into the London clay. These cylinders are 12 feet diameter and 1½ inches thick, and the mode of fixing them was, though on a very small and easy scale, much the same as that pursued with the very difficult foundations of the piers of Mr. Brunel's great bridge at Saltash. The cylinders were lowered into the places they were to occupy and forced down below the bed of the river. The water and mud were then dredged out, and the cylinder filled to a depth of nine feet with solid concrete, then 3 feet of solid brickwork, finishing with a brick invert arch, and thence a lining of 3 feet of solid brickwork up to the top of the cylinder on which the tower rests. This lining of brickwork, therefore, leaves a circular opening 6 feet wide in the cylinder down to the bed of the river, so that the work can be examined, if necessary, to its very foundations from time to time.

The ropes by which the bridge proper is suspended are of the best charcoal iron wire, and were made by Newall and Co., on the works of the bridge itself. There are two of these main ropes on each side, each being made up of 7 massive ropes banded together, and each of these 7 ropes containing 7 strands of wire, two-tenths of an inch in diameter. The sectional area of each main rope is 100 square inches, and their united strength is guaranteed to bear a strain of 4000 tons, and in detail has been proved to that amount, though the greatest strain that can come upon the bridge is only estimated at 600 tons with ordinary traffic. These ropes are secured at either end round what may be termed a massive eyebolt, with 28 screw-bolt fastenings, each fastening having already been tested with a strain of 82 tons. The "anchorage" in which all are finally secured on both sides of the river is on the Lambeth shore, where the ground is good, formed by massive iron holdfasts or beams, built into a solid masonry of concrete 20 feet below the surface. On the Westminster side, where the ground is little better than loose peat, the anchorage is made by a series of 12 square cast iron caissons, each weighing 7 tons, sunk into the gravel, and filled with concrete, and the square space thus enclosed by the whole 12 dug out and filled with concrete, so as to form one immense compact bed of iron and concrete 20 feet below the surface. Thus far, therefore, the ends of the ropes are as firmly secured as if they were taken down to the centre of gravity itself. It remains to be seen how, in this situation, the wire will resist the attacks of its great destroyer, rust. The want of efficient precautions against this apparently insignificant item of wear and tear has brought many wire-rope bridges to a premature end. From the wire ropes so secured come down a regular series of lattice tie-rod uprights, with diagonal bracings on each side, at an angle from the roadway of 45 degrees. Be-

yond that these latter are placed closer than usual, and of greater strength, there is not much that differs in principle from other suspension bridges. The roadway in suspension bridges is usually hung to the ropes and tie-rods, and there is an end of the work. In Mr. Barlow's bridge, however, a new principle is introduced, which almost, if not quite, does away with the lateral and vertical motion so dangerous to ordinary suspension bridges, and which has rendered some in this country and many in America almost useless for heavy traffic. This consists of taking under the floor of the bridge what may be called two powerful longitudinal box girders, one on each side. The sectional area of each of these is 40 inches, and each is 2 feet 3 inches deep by 18 inches wide. These diminish any upward or downward movement to a *minimum*, and absolutely check all lateral swing. To these girders, which are, in fact, the backbone of the whole structure, the lattice tie-rods we have described are fastened, and thus such rigidity is given that, calculating according to the strain wrought iron ought to bear per inch, it is said that the whole floor of the bridge, if laid sideways, would even then be strong enough for its traffic.

Between these main box girders, which run from end to end of the whole structure, wrought iron cross girders are laid at intervals of four feet apart. On these again are wrought iron plates for the roadway, which is paved with a wooden pavement, set in mineral pitch, so as to give elasticity to the thoroughfare, while securing the iron-work beneath it from the action of either air or water. The footways on each side have a width of 6 feet, though they certainly do not seem to have even this narrow limit. After the spacious sidewalks of new Westminster, these appear like mere alleys by comparison. These footpaths on each side are carried on cantilevers or iron brackets projecting from beneath the roadway. Everything being made to do some duty in the strength of this singular bridge, the parapets of the footways are formed of wrought iron lattice work, which in itself gives a support and rigidity to the otherwise light path. The paving of the footways is of Portland stone from old Westminster Bridge, cut in thin neat slabs. In the ornamental scrollwork of the brackets which carry them, the mains of the Lambeth Gas Company, 18 inches in diameter, cross the river, one under each side of the bridge. From the river these have a rather ornamental moulding appearance,—a matter in which the whole structure is, to say the least, deficient.

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

Comments on Professor Tyndal's Lecture on Force. By ELI W. BLAKE.

The lecture of Professor Tyndal, published in late numbers of this Journal, is entitled a "Lecture on Force." It might, however, be more appropriately entitled a Lecture on the Dynamic Theory of Heat. I had proposed to myself to examine some of the bold and extravagant

statements put forth in this lecture in exemplification and support of this theory; but as a popular lecture on an abstruse topic is not, perhaps, a fair subject of scientific criticism, I pass these by and make the lecture rather the occasion than the subject of this communication.

Whatever foundation there may be in nature for the dynamic theory of heat, it is certain that arguments have been employed in its behalf which are based on error. To correct one of these is the object of this paper.

Professor Tyndal states that a German named Mayer, to whom he gives the credit of having originated the dynamic theory of heat, computed the mechanical equivalent of heat from the velocity of sound. Other advocates of this theory have alleged that the mechanical equivalent thus found is in exact accordance with that deduced from other sources. No argument in behalf of the theory has been used by its advocates with more confidence and effect than this alleged coincidence; and it is not to be denied that such a coincidence, if the computations were founded upon correct and sufficient data, would be significant, and indicative of a general law governing the relations of heat to force. It is proposed to show that those who have computed the equivalent from the velocity of sound, have not been in possession of correct and sufficient data for that purpose; and consequently that the alleged coincidence, however obtained, has no such significance as has been ascribed to it.

In order to compute the mechanical equivalent of heat from the velocity of sound, it is necessary to know, first, the true theoretical velocity of the sonorous wave independently of any acceleration by heat; and secondly, we must find by experiment the actual velocity of the same wave. Then, assuming the difference of these velocities to be due to heat, and knowing the ratio in which the elastic force of the air is increased by the heat evolved by its compression, we may compute the mechanical equivalent of the heat.

Let us look at the character of the data upon which these computations have been founded. Newton, who was the first to attempt to solve the problem of the velocity of sound, arrived at the conclusion that waves of sound move with the velocity which a body would acquire by falling through half the height of a homogeneous atmosphere. But upon examining his reasoning on this subject, as given in the Principia, we shall be struck with the fact that it lacks the precision and clearness of logical sequence which usually characterize Newton's mathematical arguments. Other mathematicians, not satisfied with Newton's reasoning, yet not perceiving the true nature of its defect, have attempted to solve the problem by processes differing from that employed by Newton, yet involving the same defect. As they all arrived at the same conclusion as Newton did, it has been accepted as an established truth that the theoretical velocity of waves of sound is that which a body would acquire by falling through half the height of a homogeneous atmosphere (or about 946 feet per second), and that all sonorous waves have the same theoretical velocity. This, no

doubt, was assumed to be the theoretical velocity of sound by those who have computed from it the mechanical equivalent of heat.

In the next place we would inquire, what have they assumed to be the actual velocity of sound as found by experiment? Numerous experiments have been made by different observers, but their results differ widely, varying from 1100 feet or less, up to 1474 feet per second. Now it cannot be shown that one of these observations is less correct than another. By what rule, then, has one of them been accepted and the rest rejected? If a mechanical equivalent of a prescribed value was sought for, no doubt, within this wide range of experimental velocities, one could be selected that would meet the exigency; but what would be the value or significance of a coincidence obtained in that way?

But this is not the only nor the principal objection to the legitimacy of such a mechanical equivalent. It is not true, as here assumed, that waves of sound have all the same velocity. On the contrary, their theoretical velocities vary through a still wider range than those found by experiment.

Waves of sound are of two kinds, viz: waves of rarefaction and waves of condensation. Waves of rarefaction vary in their theoretical velocities from that which would be acquired by falling through one-fourth the height of a homogeneous atmosphere (about 668 feet per second), up to that which would be acquired by falling through one-half the height of a homogeneous atmosphere (about 946 feet per second.) Waves of condensation vary in their theoretical velocities from that which would be acquired by falling through half the height of a homogeneous atmosphere, or 946 feet per second, upward without limit. The cause of the variation in the velocities of waves of sound is their difference in intensity; that is, in the extent to which the air is condensed or rarefied in the wave. The law of variation is this, viz: the velocity of the wave is as the square root of the ratio of the density of the wave to the natural density of the air through which it moves. The velocity, 668 feet per second, is that which pertains to a wave whose density is half the natural density. This is the smallest velocity any sonorous wave can have, for the reason that if the cause which at any point originates a wave, produces at that point any greater degree of rarefaction than corresponds to a density of one-half, still the wave which will be propagated from that point will be one whose density is half the natural density. The velocity supposed by Newton and others to pertain to all sonorous waves, viz: that which a body would acquire by falling through half the height of a homogeneous atmosphere, is that which belongs to a wave whose density is equal to the natural density. This lies at the boundary between waves of rarefaction and waves of condensation. Strictly, it is the only velocity in the whole range which no wave can have, as in this case the intensity of the wave is 0.

The laws of waves, as here stated, are susceptible of rigid demonstration. The course of reasoning by which they are established may be seen by reference to an article in the American Journal of Science,

2d Series, Vol. 5, page 372. The waves contemplated in the article referred to, are waves of condensation only; but the same course of reasoning, *mutatis mutandis*, applied to waves of rarefaction, will give the results above stated as pertaining to that class of waves, with the exception of the lower limit to their range of velocities. That there is such a limit follows from the principles developed in another article in the same Journal, 2d Series, Vol. 9, page 334.

From what has been stated it follows that in order to know the true theoretical velocity of any wave of sound, we must know its density. And as the densities of the waves whose actual velocities have been observed, have not been noted by any observer, it is obvious that we do not possess the requisite data for determining the mechanical equivalent of heat from the velocity of sound.

Proceedings of the Manchester Association for the Prevention of Steam Boiler Explosions.

From the Mechanic's Magazine, November, 1862.

At the last ordinary monthly meeting of the executive committee of this association, held on Tuesday, Nov. 25, 1862, Mr. L. E. Fletcher, chief engineer, presented his monthly report, of which the following is an abstract:—

During the past month there have been examined 365 engines and 547 boilers. Of the latter 8 have been examined internally, 60 thoroughly, and 479 externally, in which the following defects have been found:—Fracture, 5 (1 dangerous); corrosion, 38 (3 dangerous); safety-valves out of order, 13; water-gauges ditto, 31; pressure-gauges ditto, 9; feed apparatus ditto, 6; blow-off cocks ditto, 47 (1 dangerous); fusible plugs ditto, 3; furnaces out of shape, 6 (2 dangerous); blistered plates, 3: deficiency of water, 1. Total 162 (7 dangerous). Boilers without glass water-gauges, 10; without pressure-gauges, 2; without blow-off cocks, 38; without back pressure-valves, 78.

An explosion has occurred this month to the boiler of a first-class passenger locomotive engine, by which 3 persons were killed and others injured. It was considered to be perfectly safe, had been on duty the previous day, and was being cleaned ready for work at the moment the explosion occurred.

It will be remembered that reference was made in the July, 1861, report, to another explosion of a locomotive boiler, which took place while the train was running; and since that time three others have occurred in addition to the one first alluded to, thus making five during that period with this class of boiler.

The cause of explosion in four of these cases proved to be thinning of the plates from internal corrosion. I have only had an opportunity of examining the plates of one of these exploded boilers, but from official reports, it appears that the corrosive action had developed itself in a very similar manner in each instance, which in the one personally examined was as follows:—The corrosion had eaten grooves or furrows parallel with and close to the edge of the overlaps of the

plates, at some of the longitudinal seams of rivets; the furrows being on the outer plates of the overlap, while the deepest one, and that from which the explosion had sprung, was situated nearly midway between the smoke-box and fire-box.

This furrowing action will be at once recognised by those who have been in the habit of observing the influence of wear upon the ordinary internally fired double-flued boiler, in general use in Lancashire. In this boiler the furrow is found on the inner surface, both of the front and back end-plates, but more especially at the front, and lies close to the edge of the internal flue angle-iron, which it partially encircles; the furrow being deepest at the crown, and gradually dying out in about six or nine inches on each side. It is sometimes found in the root of the angle-iron itself; the choice of position between the plate and angle-iron, apparently depending upon their comparative power of resistance. When the plate of the furnace-tube is flanched, the furrow more frequently occurs at the springing of the flanch than at the end-plate. Furrowing also is very commonly found at the transverse seams of rivets at the underside of boilers; the furrows in these cases being immediately at the edges of the overlaps, and most frequently on the external surface of the plates, but sometimes on the internal. This action is more severe in long boilers than in short ones, and at the middle of their length rather than at their ends. It is seldom, if ever, developed at the longitudinal seams of these boilers, except where leakage takes place, and is then found to be most severe when the objectionable plan of construction is adopted, of placing the seams of rivets in one continuous line from one end of the boiler to the other. Such are some of the manifestations of furrowing constantly met with in the boilers under the inspection of this association, and it may be interesting to attempt to trace the cause.

Furrowing appears to be the result of corrosive and mechanical action combined. The mechanical action, such as an alternate buckling of the plates, strains and frets them, and thus renders them more susceptible to the influence of corrosion than the parts at rest. Where these furrows are internal, the corrosive element is furnished by the water, which is rarely, if ever, free from acidity; and when the furrows are found externally in the flues, as explained above, the corrosion may perhaps be attributed to the influence of gases.

The cause of the buckling action varies according to the position in which it occurs.

In the stationary boilers above referred to, when found in the front end plate, it may be ascribed to the alternate elongation of the internal flues, more especially at the furnace end; and, when at the bottom of the external shell, to the unequal expansion of the plates consequent upon the different strata of temperature in the water. The temperature of these strata varies with the distance from the bottom of the boiler, in proof of which it may be stated that it is frequently found that while the water is boiling on the surface, that at the bottom of the boiler will not scald the hand. Those boilers are most conducive to this inequality of temperature which have a defective circu-

lation of water, are so set that the least heat from the fires passes beneath them, and fed with comparative cold water introduced at the bottom. It will be readily seen how these varying temperatures induce unequal expansion of the plates, and thus put upon the seams of rivets most irregular and severe strains. In this way, it is thought that the buckling action is produced, which results in furrowing at the bottom of stationary boilers.

In locomotive boilers the buckling at the longitudinal seams, in the cylindrical portion of the shell, arises from its not being of true circular form in the vicinity of the overlaps. The tendency of the internal steam pressure is to correct this, and to induce a true circular form, and thus a cross strain, which may be correctly termed a "girder strain," is put upon the plates at a short distance on each side of the line of rivets; from this a change of shape ensues, which constantly varies with the pressure of steam. The position of the furrows is found to be that of greatest elasticity, being midway between the fixed ends of the fire-box and smoke-box, just where this buckling action would have most play. It will at once be seen that the thicker the plates the greater the leverage of the girder action, and thus to thicken their edges is only to aggravate the evil. The true circular shape may be maintained, as far as appearance is concerned, by substituting a butt-strip for the overlap, but this, from its one-sidedness, will not prevent the girder action, and, indeed, tends to make two furrows instead of one. Were an inner as well as an outer butt-strip introduced, the parts would be in equilibrio, and the strain then passing through the centre of the plates, they would be subjected to their legitimate tensile strain only, and the buckling action in question set at rest.

But whatever expedients may be adopted to meet special cases, as one after another may force itself upon attention, some general precautionary measure appears to be needed to guard against the subtle influence of corrosion. It is often found, in a line of one hundred rivets, to attack ten and neglect the remainder; in an entire boiler, it will affect one or two plates and not the rest; and even in a series of boilers will select one in preference to the others. No doubt careful analysis might detect some predisposition in the metal, and thus account for the apparent anomalies, but the difficulty of foretelling the precise course of corrosion must be candidly acknowledged, and hence the necessity, as just stated, for the adoption of some sweeping precautionary measure, which will embrace every case without distinction.

The association meets the difficulty with its own members by affording them the opportunity of having what is technically termed a "thorough examination" of each of their boilers once a year, when all the seams as well as the surfaces of the plates, both outer and inner, are examined throughout, provided that the boiler is suitably prepared for the inspection. The conviction of the importance of these examinations—which such explosions as the one under consideration serve to deepen—may explain the frequency with which reference is made to this subject. Indeed, the association cannot hold itself responsi-

ble for the safety of any of the boilers under its charge, where the opportunity of making an annual "thorough examination" is withheld. In addition, it recommends to those members using multitubular boilers, that such an arrangement of tubes should be more generally adopted as will admit of a man's gaining access between them and the shell for the purpose of examination, while those should apply the hydraulic test annually, who are employing boilers which will not admit of complete examination.

From the experience derived from the boilers under the inspection of this association, it certainly appears hazardous to allow locomotives to work, as is very usually done, for five or seven years, without a complete internal examination; and it therefore becomes most important, either that some searching test should be adopted that shall at all times ascertain the sufficiency of the boilers without removing the tubes, or else that their construction shall be so modified that the parts may be rendered accessible to complete examination. The occurrence of four explosions to locomotive boilers, from internal corrosion, within the last eighteen months, must show the necessity of taking this subject into serious consideration.

Setting Boilers.—Considerable difficulty is experienced in examining many boilers from the contracted area of the flues; some, indeed, are altogether inaccessible. Boiler-setting appears to be left too much to the individual tastes of the bricklayer, and, consequently, flues of every variety of proportions are met with. A sketch has been drawn up of the proportions most generally approved, and at an early opportunity a description will be given—which space does not now permit—for the assistance of those who are re-setting their old boilers or laying down new ones; meanwhile, a drawing lies at the office of the association for the inspection of members.

Consolidated Emery Wheels.

From the London Chemical News, No. 152.

Some public trials took place last week in the Machinery Department of the International Exhibition, of Warne and Co's Consolidated Emery Wheel (Coles, Jaques, and Fanshawe's patent). The patentees have availed themselves of Walton's oxidized oil—exhibited in Class IV., 1156—as a means of consolidating emery; the mixture being formed into wheels, and then subjected to a process analogous to that by which ebonite or vulcanite is produced from india rubber. In this way a material of intense hardness and great durability is produced. The experiments we witnessed showed that a wheel of this material would grind with ease the hardest chilled iron, while steel and cast iron were cut with remarkable facility. The invention will prove of the greatest utility to engineers by saving time and labor in filing and polishing large castings—this kind of work being done with great ease and quickness. One experiment showed that the wheel could be made available for cutting teeth in circular saws, and many other applications of the material were suggested by prac-

tical engineers. We were informed that the wheels are already in use at the North London Railway Works, Bow, and some other large engineering establishments.

Description of a Feed-pipe Connexion for Locomotive Engines. By Mr. ALEXANDER ALLAN, of Perth.

From Newton's London Journal, November, 1862.

Various constructions of feed-pipe connexion between locomotive engines and tenders have been used at different times; but the double ball and socket plunger pipes, made of brass, are most generally applied, in order to have a continuous metallic connexion allowing of blowing steam through into the tender without injury. These, however, are very expensive, requiring great nicety of fitting and much care in their management in work; and in consequence of sand and dirt getting in at the movable parts, they involve a serious outlay for maintenance; and in practice it is almost impossible to keep them perfectly tight, while if the joints be too tightly screwed up there is risk of the feed-pipes breaking.

To obviate these defects, and obtain a continuous metallic connexion, comparatively inexpensive, both in first cost and maintenance, and combining simplicity, durability, and efficiency, the writer has substituted a connexion, consisting of a simple brass or copper tube, coiled to a circle of considerable diameter, so as to have sufficient elasticity to allow for the vertical disturbance due to the unequal deflection of the engine and tender springs, and also for the extreme lateral range required in going round the sharpest curves, with a minimum strain on the joints. A solid-drawn brass tube is employed, varying from No. 17 to No. 14 wire gauge in thickness, or ·060 inch to ·085 inch, coiled to a circle of 3 feet to 3½ feet diameter.

In order to offer less resistance to bending, the tubes are made elliptical in section, about 2½ inches deep by 1½ inch broad. Tubes of circular section, 2 inches in diameter, have also been used, but they are more rigid than the elliptical tubes. Experiments have been made to ascertain the amount of force necessary to stretch and compress the coiled tube, and also to deflect it vertically and laterally through the extreme range required in practice; and the results show that the ellipitical tube has the advantage in elasticity,—the first inch of deflection requiring only about 30 lbs. pressure, while a total pressure of from 90 to 100 lbs. is sufficient to produce the extreme deflection of about 3 ins. in any direction; up to this pressure there is no permanent set, and consequently no fear of the tube collapsing in any part. The experiments have been extended with the elliptical tube up to 3½ inches movement in any direction, giving a total range of 7 inches, up to which the tube may be strained safely; beyond this limit a permanent set is produced. In practice, however, the total range in any direction never exceeds 5 inches, or 2½ inches on each side of the central position,—leaving a sufficient margin of elasticity

to prevent injury to the tube. With a thinner tube or one coiled to a larger circle, an increased range could be obtained if desired.

The connecting tube is attached to both engine and tender by means of the ordinary screw and tail pipe couplings, the tail pipes being brazed upon the circular ends of the tube. It is placed above the axle, and suspended to the foot plate by short chains, so that the wheels can be removed without interfering with the feed-pipe connexion, and it is less liable to damage, should the engine get off the rails, than the ordinary ball-and-socket couplings. The connecting tube is placed central in the engine, whenever practicable, so that the angular deflection produced in running round curves is reduced to the minimum; but it can be fixed without any practical objection, in the usual side position of the feed-pipe, so as to admit of ready application to existing engines and tenders.

This connexion has been fitted to a number of locomotives on the Scottish Central Railway, including some large goods engines; and it has been subjected to severe tests during the last twelve months, and has given every satisfaction. In the engines on this railway the plan of coupling between the engine and tender, drawing as well as buffing on a heavy laminated spring, allows more movement than is usual, amounting to a play of 2 ins. between the engine and tender, and the connecting tube is 6 inches out of the centre; but even under these conditions no failure of the connecting tube has occurred. The dimensions of the engine to which it has been longest attached are—diameter of cylinder, 16 inches; stroke, 20 inches; driving wheel, 6 feet diameter; steam pressure in boiler, 130 lbs. per square inch, and boiler supplied with one No. 9 injector; and the connecting tube has now been continuously working upon this engine for nearly twelve months, with complete success, the engine having run about twenty thousand miles during the time. This tube was taken off the engine, and exhibited to the meeting: it was of circular section, and simply secured with soft solder, and no sign of its giving way was perceptible, thus proving that it is fully equal to its work. A specimen was also exhibited of a connecting tube of oval section, used on large coupled engines; in its manufacture, the tube is swaged oval in proper cresses, and is then filled with resin, and coiled to the required circle round the cast iron blocks used for blocking tyres.

—

Mr. Sampson Lloyd believed a somewhat similar plan of coupling had been tried on the South Western Railway, but did not know whether it had been successfully carried out on that line.

Mr. D. Joy thought the new coupling was the best connexion he had seen, and much superior to either the ball-and-socket coupling or the flexible hose pipes.

The Chairman inquired what was the cost and durability of the ordinary hose pipes.

Mr. D. Joy said the flexible hose pipes of canvass and india rubber were the simplest connexion, and cost only about 7s. 6d. each; but their durability was very uncertain; they lasted twelve months with

proper care, if made of good material, but sometimes failed in a single month. He thought the coupling now shown seemed as good in simplicity, and was much superior in durability; and it had an advantage in being placed close up under the foot plate, where it would be out of the way of injury if the engine got off the rails.

Mr. J. Murphy suggested that an iron tube might be used as cheaper than brass or copper.

Mr. D. Joy thought the extra cost of the brass or copper tube would be saved in the manufacture, from the greater ease of manipulation compared with iron, the total weight of metal being so small; an iron tube would also be more rigid, while the greater elasticity of brass or copper would increase the durability of the coupling.

Serrin's Automatic Electric Light.

From the London Athenæum, August, 1862.

The very ingenious automatic electric light, invented by M. V. Serrin, of Paris, exhibited among the *Instruments de Precision*, in the French Department of the Exhibition, has been shown under various phases at the Polytechnic Institution. The great difficulty in an electric light is to maintain a constantly equal distance between two charcoal points. This is effected by M. Serrin's system, and the result is a steady light of great utility. So intense, indeed, and far-reaching is the light, that small print may be read by it at a distance of three miles. M. Serrin's invention has been practically and successfully employed in carrying on railway works in Spain, where, in consequence of the great heat during the day in summer, it is impossible to carry on the works profitably excepting during the cool night hours. The experiments at the Polytechnic Institution, which will, we believe, be repeated, consist in showing the light in an atmosphere of carbonic acid, burning under water, when it is extremely brilliant, and contrasting it with the illuminating power of ordinary candles.

Explosions of Copper Gas Pipes.

From the Lond. Civ. Eng. and Arch. Jour., Oct., 1862.

Dr. T. L. Phipson states that it has been discovered that when gas pipes constructed of copper or bronze have been long submitted to the action of ordinary coal gas an explosive compound of copper and acetylen (one of the many ingredients of coal gas) is formed. When dry, this compound detonates with extraordinary violence as soon as it is rubbed, struck, or heated. Already some accidents have occurred and some workmen have lost their lives while cleaning large copper gas pipes from this circumstance. No such explosive compound appears to be formed when iron or lead are used. It is evident that large copper gas pipes are unsafe, and that some other metal should be substituted for the copper, as the latter may give rise to explosions at any moment. As concerns small pipes constructed of this metal, they

should not be allowed to get foul, and when about to be cleaned hydrochloric acid should be introduced into them for about ten minutes before they are submitted to any heat or friction. Hydrochloric acid decomposes the explosive compound, combines with the copper, and puts the acetylen in liberty. The acid may then be washed out with hot water.

For the Journal of the Franklin Institute.

On a New System of Constructing Ships, proposed to be called the Parabolic Construction. By JOHN W. NYSTROM, C. E.

The construction of ships is yet in an empirical state, with no established rules for laying down the principal lines, but is wholly dependent on skill, experience, and taste of the constructor. In the parabolic construction herein proposed, positive rules are established for the principal lines, as the load water-line, rail in plan, cross-sections, displacement, sheer, &c., that when the lines are laid down by those rules, they cannot be improved by taking in or out a little more or less here or there; the rule makes the lines right. This will enable the young constructor to lay down ship-lines as fine as if made by the most experienced shipbuilder; still he will not be confined to any particular shape or proportion of the vessel, but can vary it according to his own taste and judgment.

The advantage of the parabolic construction is not only in laying down fine lines, but the simple calculations connected with it are of great importance, and enable the constructor, with but few figures, to go to work with the greatest certainty of attaining a correct result, without recourse to trial and error, or comparison with other vessels. All the lines in a ship are combinations of the *circle*, *ellipse*, *parabola*, and *hyperbola*. These lines are derived from the conic sections, where they are curves of the second order, but herein we will employ them to any order whatever. The ordinary formula for a parabola is $y = \sqrt[n]{px}$, in which y = ordinate, x = abscissa, and p = parameter; the letter $n = 2$ in the conic parabola; it is called the *exponent*, and denotes the order of the curve. By assuming different values on the exponent n, different forms of parabolas are obtained. When $n = 0$ the parabola will be the two sides forming the right angle in a triangle; when $n = 1$ the parabola will be the hypothenuse in a right-angled triangle; when $n = 2$ it will be the true parabola in the conic sections; and when $n = \infty$ the parabola will again become the two sides forming the right angle in a triangle. The circle, ellipse, and hyperbola follow the same law, which enables us to form theoretically any line in the hull of a ship.

Referring to Plate I, figs. 1 and 2 represent parabolas of different orders from 2 to 10, the vertex being at o, x = abscissa, and y = ordinate. Figure 1 shows load water-lines of vessels of different sharp-

ness, of which the inner one is considered the sharpest form a vessel can have, being a conic parabola with the exponent $n = 2$. The higher the exponent is, the fuller will the lines be. Figure 2 represents cross-sections of vessels; the inner line is a conic parabola, and the others of higher order, same as in fig. 1. The order of the lines are marked on the drawing. The shading between every other line is to make it more distinct when selecting a desired sharpness. The water-lines and the cross-sections are precisely the same kind of lines; both can be laid down by the same ordinates.

Letters denote,

D = displacement of the vessel in cubic feet.
T = displacement in tons of salt water of 35 cubic feet to the ton.
$\mathfrak{N}$ = area of the greatest immersed cross-section in square feet.
$\mathfrak{V}$ = area of any ordinate cross-section between $\mathfrak{N}$ and the stem or stern.
L = length of the vessel in the load-line.
l = length from $\mathfrak{N}$ to where the parabola meets the centre line.
l' = the whole length from $\mathfrak{N}$ to the stem or stern, including the hollow lines.
Z = measure of the hollow lines.
B = breadth of beam in the load-line.
b = half the beam B.
d = load draft of water, omitting the depth of keel.
δ = any draft of water corresponding with the displacement t.
t = displacement in tons at the draft δ.
e = depth of centre of gravity of the displacement, under the water-line.
x = abscissa, y = ordinate.
All linear dimensions are in feet.
n = exponent for the parabola in the load water-line.
n' = exponent for the parabolas in the cross-section $\mathfrak{N}$.
n'' = exponent for the areas of the ordinate cross-sections $\mathfrak{V}$.
r = index for displacement at different drafts.
a = area of load water-line in square feet.
k = co-efficient for speed and horse power.
M = nautical miles or knots per hour.
H = horse power required for the speed M.
A = area of the hull of the boat in square feet.
$\mathbf{a}'$ = area of the upper deck, or any horizontal section of the hull at d' feet from the keel.
d' = depth from $\mathbf{a}'$ to the keel.
$\mathfrak{N}'$ = area of the greatest cross-section from the keel to $\mathbf{a}'$, or the depth d'.
e' = depth of the centre of gravity of the hull from the top of d', supposing the hull to be of uniform thickness.
a and e, see fig. 1.
m = height of metacentre above the centre of gravity of the displacement.

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Formulas.

$$y = l\sqrt[n]{\frac{b}{x}}, \quad . \quad . \quad . \quad 1$$

$$x = \frac{y^n b}{l^n}, \quad . \quad . \quad . \quad . \quad 2$$

$$n = \frac{log.\ b - log.\ x}{log.\ l - log.\ y}, \quad . \quad . \quad 3$$

$$\mathfrak{N} = \mathfrak{N}\frac{x^2}{b^2}, \quad . \quad . \quad . \quad 4$$

$$\mathfrak{a} = \frac{n\,\mathrm{B\,L}}{n+1}, \quad . \quad . \quad . \quad 5$$

$$n = \frac{\mathfrak{a}}{\mathrm{B\,L} - \mathfrak{a}}, \quad . \quad . \quad . \quad 6$$

$$\mathfrak{N} = \frac{n'\,\mathrm{B}\,d}{n'+1}, \quad . \quad . \quad . \quad 7$$

$$n' = \frac{\mathfrak{N}}{\mathrm{B}d - \mathfrak{N}}, \quad . \quad . \quad . \quad 8$$

$$\mathrm{D} = \frac{n''\,\mathfrak{N}\,\mathrm{L}}{(n''+1)\left(1+\frac{1}{2\,n''}\right)}, \quad . \quad 9$$

$$n'' = \frac{log.b - log.b\sqrt{\frac{\mathfrak{y}}{\mathfrak{Y}}}}{log.l - log.y}, \quad . \quad 10$$

$$e = \frac{d}{2}\left(\frac{n'+1}{n'+2}\right)\sqrt{\frac{n''+1}{n+2}}, \quad . \quad 11$$

$$r = \frac{(n'+1)\,(n+1)}{n'\,n''}, \quad . \quad . \quad 12$$

$$\delta = d\sqrt[r]{\frac{t}{\mathrm{T}}}, \quad . \quad . \quad . \quad 13$$

$$t = \frac{\delta^r \mathrm{T}}{d^r}, \quad . \quad . \quad . \quad . \quad 14$$

$$y = \sqrt[n]{b^n - \left(\frac{b\,x}{l}\right)^n}, \text{ Ellipse,} \quad 15$$

$$l' = l\left(2\sqrt[n]{\frac{b-z}{b}} - \sqrt[n]{\frac{b-2z}{b}}\right), 16$$

$$l = \frac{l'}{2\sqrt[n]{\frac{b-z}{b}} - \sqrt[n]{\frac{b-2z}{b}}}, \quad 17$$

$$c = l\left(1 - \sqrt[n]{\frac{b-z}{b}}\right), \quad . \quad 18$$

$$a = l' + c - l, \quad . \quad . \quad . \quad 19$$

$$\mathrm{A} = 2\sqrt{\frac{n''}{n+1}}\left(\mathfrak{N}' + d'\mathrm{L}\right) + \mathfrak{a}', 20$$

$$\mathrm{H} = \frac{\mathrm{M}^3\,\mathfrak{N}}{k\,\mathrm{L}}, \quad . \quad . \quad . \quad . \quad 21$$

$$\mathrm{M} = \sqrt{\frac{k\cdot\mathrm{L\,H}}{\mathfrak{N}}}, \quad . \quad . \quad . \quad 22$$

$$m = \frac{\mathrm{B}^3}{12\,\mathfrak{N}^3}\sqrt{\frac{\mathrm{D}}{\mathrm{L}\,\mathfrak{N}}}, \quad . \quad . \quad 23$$

$$m = \frac{\mathrm{B}^3}{12\,\mathfrak{N}^3}\sqrt{\frac{n}{(n+1)\left(1+\frac{1}{2\,n''}\right)}} 24$$

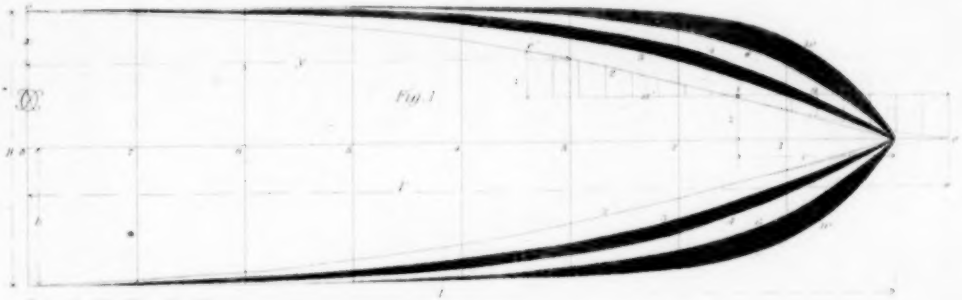
$$n'' = \frac{1}{\mathfrak{N}\,\mathrm{L} + \mathrm{D}}\left(\sqrt{\mathfrak{N}\,\mathrm{L\,D} + 0{\cdot}4375\,\mathrm{D}^2} - 0{\cdot}75\,\mathrm{D}\right), \quad . \quad . \quad . \quad 25$$

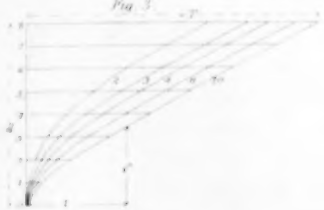
$$e' = \frac{d'(d'\mathrm{L} + \mathfrak{a} + \mathfrak{N}')}{2\,d'\mathrm{L} + \mathfrak{a} + 2\,\mathfrak{N}'}\left(\frac{n'+1}{n'+2}\sqrt{\frac{n''+1}{n+2}}\right), \quad . \quad . \quad . \quad . \quad . \quad 26$$

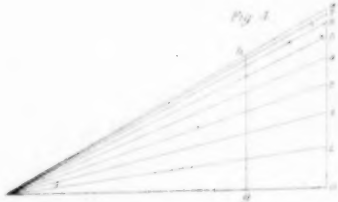
TABLE I.

Exp. n	ORDINATES AND CROSS-SECTIONS. 1	2	3	4	5	6	7	8	Area W L sq. ft. / Disp. cub. ft.	Cent. grav. e. / Disp. tons.	Exp. r. / Coeff. k.
2	·2345	.4375	·6094	·7500	·8593	·9375	·9844	b	$a = ·6666$ B L	$e = ·325\ d$	$r = 2·25$
	·0546	·1914	·3713	·5625	·7384	·8909	·9688	$\mathcal{N}$	D $= ·5333\ \mathcal{N}$ L	T $= ·0152\ \mathcal{N}$ L	$k = 1·94$
2½	·2838	·5129	·6912	·8232	·9139	·9687	·9944	b	$a = ·7142$ B L	$e = ·343\ d$	$r = 2·00$
	·0505	·2512	·4778	·6777	·8352	·9383	·9889	$\mathcal{N}$	D $= ·5952\ \mathcal{N}$ L	T $= ·0170\ \mathcal{N}$ L	$k = 2·00$
3	·3301	·5781	·7558	·8750	·9472	·9844	·9980	b	$a = ·7700$ B L	$e = ·358\ d$	$r = 1·77$
	·1090	·3342	·5713	·7667	·8972	·9691	·9960	$\mathcal{N}$	D $= ·6429\ \mathcal{N}$ L	T $= ·0184\ \mathcal{N}$ L	$k = 1·94$
3½	·3733	·6346	·8070	·9116	·9677	·9922	·9993	b	$a = ·7777$ B L	$e = ·370\ d$	$r = 1·71$
	·1394	·4027	.6512	·8310	·9365	·9845	·9986	$\mathcal{N}$	D $= ·6806\ \mathcal{N}$ L	T $= ·0194\ \mathcal{N}$ L	$k = 1·88$
4	·4138	·6836	·8474	·9375	·9802	·9961	·9997	b	$a = ·8000$ B L	$e = ·381\ d$	$r = 1·56$
	·1712	·4673	·6858	.8789	·9608	·9922	·9994	$\mathcal{N}$	D $= ·7111\ \mathcal{N}$ L	T $= ·0203\ \mathcal{N}$ L	$k = 1·82$
5	·4871	·7627	·9046	·9687	·9926	·9990	·9999	b	$a = ·8333$ B L	$e = ·397\ d$	$r = 1·44$
	·2373	·5817	·8183	·9384	·9853	·9980	·9998	$\mathcal{N}$	D $= ·7575\ \mathcal{N}$ L	T $= ·0216\ \mathcal{N}$ L	$k = 1·70$
6	·5512	·8220	·9404	·9843	·9972	·9997	1·0000	b	$a = ·8666$ B L	$e = ·409\ d$	$r = 1·36$
	·3038	·6757	·8844	·9688	·9944	·9995	·9999	$\mathcal{N}$	D $= ·7912\ \mathcal{N}$ L	T $= ·0226\ \mathcal{N}$ L	$k = 1·58$
8	·6564	·8989	·9767	·9960	·9996	·9999	1·0000	b	$a = ·8888$ B L	$e = ·426\ d$	$r = 1·26$
	·4309	·8080	·9540	·9920	·9992	·9998	1·0000	$\mathcal{N}$	D $= ·8155\ \mathcal{N}$ L	T $= ·0233\ \mathcal{N}$ L	$k = 1·34$
10	·7369	·9437	·9909	·9990	·9999	1·0000	1·0000	b	$a = ·9090$ B L	$e = ·458\ d$	$r = 1·21$
	·5430	·8906	·9819	·9980	·9998	·9999	1·0000	$\mathcal{N}$	D $= ·8666\ \mathcal{N}$ L	T $= ·0248\ \mathcal{N}$ L	$k = 1·18$

Parabolic Construction of Ships







T. Sinclair's lith. Phila.

Explanation of Formulas.

The parabolic formulas 1 and 2 are for calculatiug the curvature of the load water-line and cross-section. The abscissa x, subtracted from b, gives the ordinate from the centre line of the vessel to the water-line or cross-section. Formula 3 is for finding the exponent of the water-line. Formula 4 gives the ordinate immersed cross-sections between $\mathfrak{X}$ and the stern or bow. In the accompanying table ordinates and cross-sections are calculated for eight places between $\mathfrak{X}$ and the stem or stern, numbered as shown in the table, and figures 1 and 2.

Example 1. Required the fourth ordinate of a water-line with the exponent $n=3$ and $b=18$ feet. See table, exponent 3, line b in the 4th column. Ordinate $0{\cdot}8750\times18=15{\cdot}75$ feet, the answer.

Example 2. Required the area of the 3d, for the exponent $n''=4$, $\mathfrak{X}=455$ square feet. See table, exponent 4, line $\mathfrak{X}$, 3d column. $\mathfrak{w}=0{\cdot}6858\times455=312{\cdot}1$ square feet, the answer.

The exponent n need not be alike, fore and aft, but n'' must be the same, so that the area $\mathfrak{w}$ be equal for the same number of ordinates fore and aft of $\mathfrak{X}$. This rule should be carefully observed.

Example 3. Required the area of the load water-line of a vessel L = 255 feet, B = 28 feet, and the exponent $n=3\frac{1}{2}$?

Formula 5. $$\mathfrak{a}=\frac{3{\cdot}5\times28\times255}{3{\cdot}5+1}=5553{\cdot}3 \text{ square feet.}$$

Example 4. The greatest immersed cross-section $\mathfrak{X}=307$ square feet, B=32 feet, and $d=12$ feet. Required the exponent n'?

Formula 8. $$n'=\frac{307}{32\times12-307}=4, \text{ the answer.}$$

Example 5. A ship of $\mathfrak{X}=307$ square feet, L = 250 feet long, and the exponent $n''=4$. Required the displacement D in cubic feet?

Formula 9. $$\text{D}=\frac{4\times307\times250}{(4+1)\left(1+\frac{1}{2\times4}\right)}=54577 \text{ cubic feet.}$$

Formula 25 is for finding the exponent n'' when $\mathfrak{X}$, D and L are given.

Formula 10 is for finding the exponent n'', when $\mathfrak{X}$, $\mathfrak{w}$, l, b, and the distance y between $\mathfrak{X}$ and $\mathfrak{w}$ are given.

The *formulas* 3, 6, 8, 10, and 25 will give the exponents for any vessel.

Example 6. A vessel of $d=12$ feet draft of water (depth of keel omitted), constructed with the exponents $n=3$, $n'=6$ and $n''=3$. Required the depth of the centre of gravity of displacement under water-line?

Formula 11. $$e=\frac{12}{2}\left(\frac{6+1}{6+2}\right)\sqrt{\frac{3+1}{3+2}}=4{\cdot}695 \text{ feet.}$$

The centre of gravity of the displacement in the length of the vessel will always be halfway between $\mathfrak{X}$ and the middle of L.

Example 7. A vessel constructed with the exponents $n=2\frac{1}{2}$, $n'=4$ and $n''=2\frac{3}{4}$. The load draft of the vessel is $d=16$ feet, when the displacement $T=4500$ tons. Required her displacement $t=?$ at $\delta=9$ feet draft.

Formula 12. Index $r=\dfrac{(4+1)\,(2{\cdot}5+1)}{4\times 2{\cdot}75}=1{\cdot}59.$

Formula 14. $t=\dfrac{9^{1{\cdot}59}\times 4500}{16^{1{\cdot}59}}=1432$ tons, the answer.

The launching draft is calculated by the formula 13, when $t=$ weight of the vessel in tons.

The formula 15 is for calculating the elliptic form of the stern-rail or deck; its nature is the same as that of the parabolic formula 1, namely, the higher the exponent is, the fuller will the line be.

Ordinates for ellipses of different orders from 2 to 4, are calculated and contained in the accompanying Table II. Half the greatest rail-beam multiplied by the tabular number, gives the corresponding ordinate in the stern-rail ellipse.

See fig. 8, where the stern-rail is an ellipse of the third order or $n=3$.

TABLE II. *Elliptic Stern of Vessels.*

Expo't.	ORDINATES FOR ELLIPSES OF DIFFERENT ORDER.							
n	$\frac{1}{2}$	1	2	3	4	5	6	7
2	·3398	.4840	·6616	·7808	·8660	·9204	·9682	·9922
$2\frac{1}{4}$	·4108	·5490	·7147	·8274	·9004	·9495	·9801	·9958
$2\frac{1}{2}$	·4670	·5537	·7657	·8627	·9252	·9646	·9873	·9978
$2\frac{3}{4}$	·5174	·6514	·8029	·8901	·9434	·9749	·9932	·9989
3	·5604	·6911	·8331	·9019	·9565	·9821	·9948	·9994
$3\frac{1}{4}$	·5991	·7252	·8578	·9275	·9664	·9871	·9973	·9996
$3\frac{1}{2}$	·6333	·7548	·8782	·9406	·9740	·9907	·9978	·9998
4	·6906	·8021	·9093	·9595	·9840	·9950	·9995	·9999
Sheer	30°	·0149	·0582	·1321	·2374	·3740	·5449	·7531
of	45°	·0157	·0539	·1221	·2152	·3517	·5227	·7313
Vessels.	60°	.0160	·0474	·1086	·1972	·3190	·4794	·6946

Sheer. The sheer lines are calculated for circle-arcs of 30°, 45°, and 60°; they will be ellipses of the second order; for 30° the elliptical form is hardly perceptible, but for 60° it is more so.

Dead Flat. There is a difference of opinion among shipbuilders as to where to place the *dead flat* ✕. Some place it forward, some abaft, and some in the middle of the vessel. It appears that on sailing vessels the *dead flat* should be located forward, on account of the centre of effort of the sails being high above the ship. In paddle steamers the *dead flat* should be located in the centre, and in propellers abaft the centre. In sailing yachts the *dead flat* is most generally abaft the centre.

The yacht *America*, which won the prize at the exhibition in London in 1851, had her *dead flat* about $\frac{3}{8}$ths from the stern. The yacht

America is a perfect model of the parabolic construction; her exponents are $n=n'=2$, and $n''=2\frac{1}{4}$, with no hollow lines.

The clipper ship *Great Republic* had her *dead flat* abaft the centre, and the centre of effort of her sails was about 12 feet ahead of the centre of gravity of her displacement. This is an exceptional case; in sailing vessels the *dead flat* is most generally placed forward of the centre.

Hollow Lines. It is the fashion in our days to make the load water-line hollow fore and aft, which fancy is only pleasing and deceiving to the eye. Experiments have been made with a view to find out some less resistance to vessels with hollow lines, but have not, that I am aware of, given any satisfactory results. The hollow lines take away a good portion of the displacement, and diminish the strength and stability of the vessel. In order to follow up the fashion I will here describe how hollow lines are formed in the Parabolic construction. Let i fig. 1 be the point where the hollow line is to commence; draw through i a line parallel to the centre line, draw the ordinate z, find $z'=z$, make $a=a'$, then e is the stem or stern of the boat. Draw equal number of ordinates on a and a', by which the line $e'\,i$ is transferred to $i\,e$, and forms the hollow part of the water-line. The ordinate z is the measure of the hollow line, and ought not to exceed $z=\frac{1}{3}\,b$. The formulas 16, 17, 18, and 19, are for calculating different parts connected with the hollow line as will be understood by refering to figs. 1 and 8. Should it be desired to be very fashionable, we can even form a wave-line by the parabolas.

The Hull of Vessels. The area A of the hull of a boat will be found by the formula 20.

Example 8. A vessel constructed with the exponents $n=n''=4$, $\mathfrak{M}=307$ sq. ft., $d=12$ feet, L $=250$ feet, and the area of the water-line a $=5600$ sq. ft. Required the area of the immersed portion of the hull?

Formula 20. $$\text{A}=2\sqrt{\frac{4}{4+1}}\left(307+12\times 250\right)+5600=11516$$

sq. ft. If the vessel is to be coppered add 15 per cent. to the area A, and it gives the surface of copper required to cover the immersed portion of the hull, including the lap.

Example 9. A vessel of the same dimensions as in the preceding example has the upper deck 8 feet above the load water-line; the beam B $=28$ feet, makes $d'=12+8=20$ feet, and $\mathfrak{M}=307+28\times 8=531$ sq. feet, area of the upper deck, $\mathfrak{a}'=6720$ sq. ft. Required the area of the hull from the keel to the upper deck?

$$\text{A}=2\sqrt{\frac{4}{4+1}}\left(531+20\times 250\right)+6720=16614 \text{ sq. ft.}$$

Example 10. Suppose the hull of the vessel in the preceding examples to be of $\frac{1}{2}$-inch plate iron, and add 15 per cent. to the area A, for lap and rivets. Required the weight of the hull in tons, from the keel to the upper deck?

$$\text{A}=16614\times 1{\cdot}15=19106 \text{ sq. feet.}$$

The weight of ½-inch iron is 20 pounds per square foot, when the weight of the hull will be

$$\frac{19106 \times 20}{2240} = 171 \text{ tons, nearly.}$$

Example 11. Suppose the distance between the frames to be 18 inches or 1·5 feet. Required the length of all the frames to the upper deck? From example 9 we have A = 16614 sq. feet., when the length of the frames will be

$$\frac{16614}{1{\cdot}5} = 11076 \text{ feet, the answer.}$$

Example 12. Required the depth of the centre of gravity in the hull of a vessel with dimensions as in the preceding examples. The exponent for the cross section $n' = 10$. The bulwark and keel omitted. Length of upper deck L = 262 feet.

Formula 26. $e' = \frac{20\ (20 \times 250 + 5600 + 531)}{2 \times 20 \times 250 + 5600 + 2 \times 531} \left(\frac{10+1}{10+2} \right) \sqrt{\frac{4+1}{4+2}} = 11{\cdot}2$ feet.

It will be seen that the *exponents* perform the most prominent part, both in the calculation and construction. By proper selection of the exponents any form of vessels can be constructed by the parabolic method.

The formula 21 is for calculating the horse power necessary for a given speed; the co-efficient k will be found in table I. last column, in the line of the given exponent for the displacement.

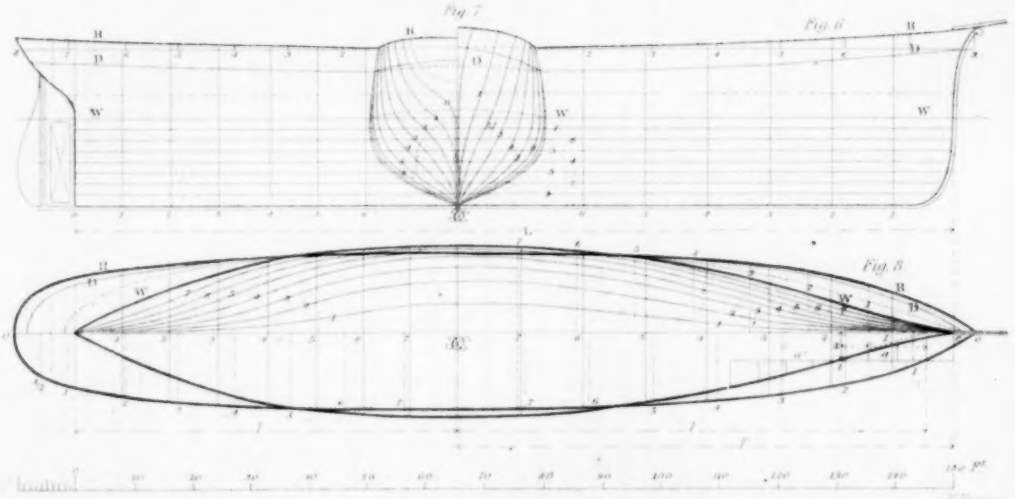
Example 13. What power is required for a vessel of dimensions as in the preceding examples, to propel her M = 9 knots per hour? $n'' = 4$ $k = 1{\cdot}82$, $\mathfrak{M} = 307$ and L = 250.

$$\textit{Formula } 21. \quad \text{H} = \frac{9^3 \times 307}{1{\cdot}82 \times 250} = 491{\cdot}8 \text{ horses.}$$

Figure 3. Is a scale of displacement at different drafts of water; it is calculated and constructed by the formulas 13 and 14. The numbers on the curves denote the exponent n of the vessel, and not the index r. The displacement T is represented by the 8th water-line from the figure 8 to where it meets the curve; all the other water-lines represent the displacement t at the noted draft.

Figure 4. Is a diagram for laying out the ordinates in the water-line and cross-section; one of these should be constructed for each exponent n. This diagram is constructed with the exponent $n = 2$, the line $g\ h = b$, figs. 1 and 2, and the ordinates in the inner parabola corresponds with the distances from g in the diagram. It is constructed in the following way: Make a right-angled triangle of any desired size; make the base longer than the height; call the height = 1; decide the exponent for the diagram; set off from the right angle the ordinates in the line b Table I, and join them with the opposite angle in the triangle; then any beam b set off at right angle from the base to the hy-

Nystrom's Parabolic Construction of Ships.



T. Sinclair's lith. Phila.

pothenuse gives the corresponding ordinates in the water-line or cross-section.

Figure 5. Shows how to lay out the spring of the beams; the length is divided into 8 equal parts from each end, numbered as shown by the figure. The spring of deck beams ought to be a parabola of the second order, when the ordinates are calculated from the line b, exponent 2, Table I; the spring $b=1$.

Parabolic Construction of a Propeller Steamer. Plate II.

Figures 6, 7, and 8 are constructions of a steam propeller of the following dimensions.

L = 150 feet, length in the load water-line.

B = 30 feet, breadth of beam.

$d=15$ feet, draft of water, omitting the depth of the keel.

The scale is $\frac{1}{8}$ of an inch to the foot.

Figure 8. The exponents are selected as follows: $n=2$ of the forward water-line, with hollow lines of $z=5$ feet, or $\frac{1}{3}$ of b; for the aft water-line; $n=2\frac{1}{2}$, with no hollow lines; $\mathcal{M}$ is located $\frac{1}{16}$ of the length abaft the middle of L, making 84·375 feet forward and 65·625 feet aft of $\mathcal{M}$. The length l from $\mathcal{M}$ to where the parabola meets the centre line is calculated by the formula 17, and found to be $l=79·9$ feet, which makes the parabola cut the centre line 84·375—79·9= 4·475 feet from the stem; the length l is divided into 8 equal parts fore and aft; draw the ordinates, number them, and set off the corresponding distances from the centre line as calculated and contained in the water-line columns, Table III., then draw the water line.

Hollow Lines. Find the distance c by the formula 18, draw the ordinate z and the parallel line $a'\ a$, transfer the hollow line as before described, then divide the whole length l' into 8 equal parts for the ordinate cross-sections $\mathcal{W}$.

TABLE III. *Ordinates for a Propeller Steamer.*

Ordinates.	Cross. $n'=3$ $\mathcal{M}$	Disp't. $n''=2$ half $\mathcal{W}$	WATER-LINE. $n=2$ forward.	WATER-LINE. $n=2\frac{1}{2}$ abaft.	RAIL. $n=4$ forward.	RAIL. $n=3$ abaft.	SHEER. 45° forward.	SHEER. 45° abaft.
1	4·951	9·450	3·517	4·257	5·591	9·340	0·047	0·023
2	8·671	33·15	6·562	7·693	9·230	11·24	0·161	0·081
3	11·33	64·50	9·141	10·36	11·44	12·18	0·366	0·183
4	13·12	97·50	11·25	12·33	12·66	12 92	0·645	0·322
5	14·21	128·0	12·89	13·71	13·24	13·26	1·055	0·527
6	14.76	154·0	14·06	14·53	13·44	13·42	1·570	0·785
7	14·97	167·5	14·76	14·91	13·49	13·49	2·195	1·097
8	15 ft.	173·2	15 ft.	15 ft.	13·5 ft.	13·5 ft.	3 ft.	1·5 ft.

The exponent for the cross-section, fig. 7 $n'=3$, when the area will be formula 7, $\mathcal{M}=346·5$ square feet; divide the depth d into 8 equal parts, draw and number the ordinate water lines, set off from the centre line the corresponding distances in the second column, Table III., and draw

the line forming the cross-section; continue it above the water-line according to your own taste and judgment, and the purpose for which the vessel is to be used. It is in this case continued 12 feet to the rail, where the rail beam is b=27 feet. Draw the longitudinal section, fig. 7 with the form of the stem, stern, and sheer; transfer the whole length to the plan fig. 8. The forward rail is a parabola of exponent $n=4$, and the aft rail an ellipse of exponent $n=3$. Divide the whole length from $\mathfrak{X}$ fore and aft, into 8 equal parts, draw and number the ordinates as shown by the dotted lines, set off from the centre line the corresponding distances in the rail columns, Table III., and draw the rail. The sheer of the rail is 3 feet on the stem and 1·5 feet on the stern, formed by a 45° curve, Table II., and the ordinate heights in the sheer column, Table III.

Displacement. The exponent for the displacement is $n''=2$, and the area of half the ordinate cross-sections $\mathfrak{O}$ are contained in the third column, Table III. The forth sections fore and aft $\mathfrak{O}_4=97{\cdot}5$ sq. feet, is drawn first, fig. 6; then the second $\mathfrak{O}_2=33{\cdot}15$ sq. feet, and the sixth $\mathfrak{O}_6=154$ sq. feet are laid down fore and aft. The ordinate water-lines, fig. 8 are now drawn, after which the remaining cross-sections $\mathfrak{O}_1$, $\mathfrak{O}_3$, $\mathfrak{O}_5$, and $\mathfrak{O}_7$, are inserted. In case the ordinate division does not correspond with the frame division, these three sections $\mathfrak{O}_4$, $\mathfrak{O}_2$, and $\mathfrak{O}_6$, fore and aft may be sufficient to give the form of the boat, after which the regular frame division is made and the frames drawn as in the ordinary construction of ships. There are various modes for calculating the areas of the sections $\mathfrak{O}$, and the most simple and sufficiently correct one is to add the eight ordinates, taking only half of the 8th one, and the sum multiplied by the distance between them, gives the area very near. Another mode more simple and correct, is by an instrument invented by Mr. Amsler, called the *Planometer*, which will be described at the end of this article. The table III. should always be calculated before the construction is commenced.

The displacement is calculated from the formula 9. $\mathrm{D}=27718{\cdot}267$ cubic feet, and $\mathrm{T}=791{\cdot}95$ tons.

Example 14. The centre of gravity of the displacement is found by the formula 11, $e=5{\cdot}04$ feet under the water line, when the medium of the exponent $n=2\frac{1}{4}$. In the length the centre of gravity will be

$$\frac{34{\cdot}375-75}{2}=4{\cdot}6875 \text{ feet forward of } \mathfrak{X}.$$

The index for displacement will be,

$$\textit{Formula } 12.\quad r=\frac{(3+1)\,(2\frac{1}{4}+1)}{3\times 2}=2{\cdot}16.$$

Required how much water the vessel will draw with a displacement of $t=310$ tons?

$$\textit{Formula } 13.\quad \delta=15\sqrt[2{\cdot}16]{\frac{310}{792}}=9{\cdot}716 \text{ feet, the answer.}$$

The formulas 23 and 24 are for finding the height of metacentre m, above the centre of gravity of the displacement.

Example 15. Required the height of metacentre in the propeller steamer, where $\text{B} = 30$ feet, $\mathscr{M} = 346{\cdot}5$ square feet, $\text{L} = 150$ feet, and $\text{D} = 27718$ cubic feet.

$$m = \frac{30^3}{12 \times 346{\cdot}5} \sqrt[3]{\frac{27718}{150 \times 346{\cdot}5}} = 5{\cdot}266 \text{ feet.}$$

I will avail myself of this opportunity to make a correction in the article on *Stability of Vessels in Water*, published in the last July number of this Journal. There is an error in the formula 1, page 54, which extends through nearly all the examples.

Formula 1. $b = \frac{\text{D B}^3 \, tan.\, v}{772 \, \text{L} \, \mathscr{M}^2}$, should be $= \frac{\text{B}^3 \, tan.\, v}{12 \, \mathscr{M}} \sqrt{\frac{\text{D}}{64{\cdot}3 \, \text{L} \, \mathscr{M}}}$.

Also, the formula 7, should be

$$col.\, v = \frac{\text{D}}{\text{W L}} \left(\frac{\text{B}^3}{12 \, \mathscr{M}} \sqrt[3]{\frac{\text{D}}{64{\cdot}3 \, \text{L} \, \mathscr{M}}} \pm a \right) = \frac{\text{D}}{\text{W L}} \left(m \pm a \right).$$

In the formula 6, the last term b should be negative, or $-b$.

These corrections are made in the seventh edition of Nystrom's Pocket Book.

By differentiating the formula 14, $t = \frac{\text{T} \, \partial^r}{d^r}$, in which T and d are constants, t and ∂ the variables, we have

$$\mathfrak{d}t = \frac{r \, \text{T} \, \partial^{r-1} . \mathfrak{d}\partial}{d^r}, \text{ and } \mathfrak{d}\partial = \frac{d^r . \mathfrak{d}t}{r \, \text{T} \, \partial^{r-1}}$$

$\mathfrak{d}t$ = increment of the displacement, and $\mathfrak{d}\partial$ = increment of the draft of water.

Example 16. It is required to know how much ($\mathfrak{d}t = ?$) the propeller steamer can be loaded per $\mathfrak{d}\partial = 1$ inch or $\frac{1}{12}$ foot of additional draft of water, at a draft $\partial = 12$ feet?

From the preceding examples we have $r = 2{\cdot}16$, $\text{T} = 792$ tons, and $d = 15$ feet.

$$\mathfrak{d}t = \frac{2{\cdot}16 \times 792 \times 12^{1{\cdot}16}}{15^{2{\cdot}16} \times 12} = 7 \text{ tons, the answer,}$$

which will sink the steamer one inch.

Example 17. The vessel is loaded to a draft of $\partial = 13$ feet. How much ($\mathfrak{d}\partial = ?$) will the vessel sink by charging her with $\mathfrak{d}t = 20$ tons more?

$$\mathfrak{d}\partial = \frac{15^{2{\cdot}16} \times 20}{2{\cdot}16 \times 792 \times 13^{1{\cdot}16}} = 0{\cdot}202 \text{ feet} = 2{\cdot}284 \text{ inches, the answer.}$$

The principal formulas, tables, and examples of the parabolic construction of ships, are contained in the seventh edition of Nystrom's Pocket Book of Mechanics and Engineering, where there is not room for a complete explanation on the subject.

Displacement.	NAUTICAL MILES OR KNOTS PER HOUR.							
	5	6	7	8	9	10	11	12
T	H	H	H	H	H	H	H	H
100	11·8	19·4	32·4	48·4	68·5	94·5	126	163
200	18.8	32·5	51·5	76·9	110	150	200	260
300	24·5	42·4	67·5	100	142	196	262	340
400	29·8	51·4	81·7	122	172	238	317	412
500	34·6	59 6	94·3	141	200	276	368	478
600	39·0	67·2	107	160	226	313	415	540
700	43 3	74·6	119	177	250	377	460	599
800	47·3	81·5	130	194	274	378	503	654
900	51·1	88·1	140	210	296	409	545	708
1000	54·9	94·6	150	225	318	439	585	759
1100	58·4	100	160	239	338	467	622	806
1200	62·0	107	170	254	359	495	660	858
1300	65·3	112	179	267	378	523	696	903
1400	68·7	119	189	281	398	549	732	950
1500	71·9	124	197	295	417	575	766	995
1600	75·0	130	206	307	435	600	800	1038
1700	78·1	135	215	320	453	625	833	1083
1800	81·2	140	224	332	470	649	864	1123
1900	84·2	145	231	345	488	673	897	1166
2000	87·0	150	239	356	504	696	927	1205
2100	90·0	155	247	369	521	720	958	1247
2200	92·7	160	255	380	537	741	988	1284
2300	95·6	165	262	391	554	764	1017	1324
2400	98·4	170	270	402	569	786	1047	1360
2500	101	174	277	414	585	808	1077	1400
2600	104	179	285	424	600	828	1102	1435
2700	106	184	292	436	616	850	1131	1473
2800	109	188	299	446	631	871	1160	1508
2900	111	192	306	457	646	893	1189	1545
3000	114	197	313	467	660	913	1215	1582
3100	117	201	320	478	676	933	1242	1614
3200	119	205	327	488	690	952	1268	1648
3300	121	209	334	498	704	972	1296	1683
3400	124	214	340	508	718	992	1320	1717
3500	127	218	347	518	733	1010	1347	1750
3600	129	222	354	528	746	1025	1373	1783
3700	131	226	360	538	759	1049	1398	1815
3800	133	230	367	548	774	1070	1422	1848
3900	135	234	373	558	787	1087	1446	1880
4000	138	238	380	567	801	1105	1473	1912
4100	140	242	386	577	814	1122	1497	1944
4200	142	246	392	586	827	1141	1520	1975
4300	155	250	398	595	840	1160	1545	2008
4400	147	254	404	604	853	1179	1568	2037
4500	150	258	410	613	866	1198	1593	2070
4600	152	261	416	622	879	1216	1614	2100
4800	156	270	428	640	904	1248	1663	2160
5000	160	277	440	658	929	1332	1708	2220
5500	171	295	469	700	990	1367	1822	2365
6000	181	303	497	742	1050	1448	1930	2507

Displacement.	NAUTICAL MILES OR KNOTS PER HOUR.							
	13	14	15	16	17	18	19	20
T	H	H	H	H	H	H	H	H
100	207	259	318	387	464	551	648	756
200	329	412	506	615	737	875	1027	1201
300	432	540	662	806	966	1146	1347	1573
400	522	654	803	976	1170	1402	1632	1907
500	607	759	932	1131	1358	1611	1896	2213
600	684	856	1036	1280	1532	1820	2140	2500
700	759	938	1166	1417	1700	2016	2373	2770
800	830	1038	1274	1548	1857	2206	2593	3026
900	898	1123	1380	1675	2009	2385	2803	3274
1000	963	1206	1480	1798	2157	2560	3008	3514
1100	1024	1284	1574	1913	2295	2723	3203	3736
1200	1090	1360	1670	2030	2435	2890	3400	3967
1300	1147	1432	1758	2136	2564	3043	3576	4178
1400	1204	1508	1850	2248	2697	3200	3762	4394
1500	1264	1580	1938	2355	2825	3352	3943	4605
1600	1317	1648	2020	2458	2948	3500	4113	4803
1700	1374	1718	2107	2561	3072	3646	4286	5006
1800	1422	1784	2188	2660	3190	3785	4448	5195
1900	1479	1850	2270	2760	3310	3928	4615	5390
2000	1527	1913	2345	2854	3420	4060	4770	5570
2100	1582	1979	2382	2948	3535	4195	4935	5762
2200	1628	2037	2500	3038	3642	4325	5084	5935
2300	1680	2102	2578	3134	3755	4460	5241	6120
2400	1723	2160	2646	3220	3860	4580	5386	6290
2500	1777	2222	2725	3313	3970	4715	5542	6470
2600	1820	2280	2796	3400	4075	4835	5655	6637
2700	1870	2338	2868	3486	4180	4960	5832	6813
2800	1911	2395	2935	3568	4280	5076	5970	6970
2900	1960	2452	3010	3655	4385	5200	6115	7142
3000	2000	2508	3075	3740	4485	5318	6255	7300
3100	2048	2565	3145	3822	4585	5440	6394	7470
3200	2092	2616	3210	3905	4680	5550	6525	7622
3300	2134	2671	3280	3985	4775	5670	6666	7781
3400	2178	2725	3343	4063	4870	5784	6784	7936
3500	2220	2779	3408	4143	4965	5893	6936	8090
3600	2264	2830	3475	4222	5060	6010	7061	8250
3700	2303	2881	3534	4300	5155	6115	7184	8400
3800	2348	2941	3606	4385	5250	6238	7333	8563
3900	2385	2986	3660	4453	5340	6336	7444	8695
4000	2427	3038	3725	4530	5430	6444	7580	8847
4100	2468	3086	3785	4610	5520	6550	7700	8988
4200	2507	3137	3850	4680	5610	6655	7830	9141
4300	2546	3186	3910	4750	5700	6761	7950	9285
4400	2585	3238	3970	4825	5790	6865	8072	9432
4500	2624	3286	4025	4900	5875	6970	8195	9572
4600	2664	3333	4087	4970	5960	7070	8320	9710
4800	2740	3431	4202	5113	6130	7275	8555	9990
5000	2817	3525	4321	5253	6300	7475	8792	10250
5500	3000	3755	4608	5600	6715	7972	8370	10953
6000	3180	3981	4880	5935	7120	8446	9935	11586

Steamship Performance.

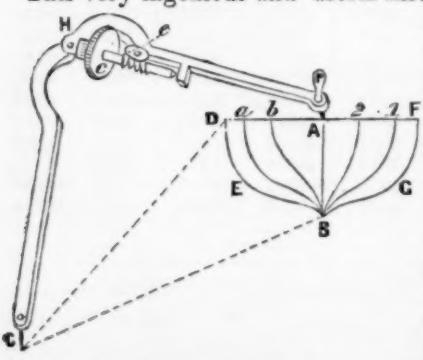
This subject has received a great deal of attention by operative minds, but has not yet been satisfactorily established. We know that the resistance is in proportion to the square of the velocity, multiplied by the area projecting to the motion; that if we know the performance of one vessel, we can easily find the performance of any other vessel of equal proportions; but when this proportion varies, the subject becomes more intricate. We therefore know that the resistance is a function of $M^2 \mathfrak{M}$, and consequently the power or mechanical effect required to propel the vessel, is a function of $M^3 \mathfrak{M}$. The displacement D is a function of the cube of any linear dimension of the same, and the greatest immersed section $\mathfrak{M}$ a function of the square of any linear dimension of the displacement, consequently the $\sqrt[3]{D}$ is a function of any linear dimension of D, and $(\sqrt[3]{D})^2 = \sqrt[3]{D^2}$ is a function of $\mathfrak{M}$; therefore the resistance is a function of $M^2 \sqrt[3]{D^2}$, and the mechanical effect, which we may call the horse power H, is a function of $M^3 \sqrt[3]{D^2}$. If we know the performance of one vessel to be $\frac{M^3 \sqrt[3]{D^2}}{H} = C$, a co-efficient, we can thereby ascertain the performance of any other vessel of the same proportions, or $H = \frac{M^3 \sqrt[3]{D^2}}{C}$, and $M = \frac{\sqrt[3]{H C}}{D^2}$.

The preceding tables are calculated by these formulas, for vessels of the following proportions:—the length $L = 6$ B breadths, and the exponent for the displacement $n'' = 2\frac{1}{2}$, which makes a very sharp vessel.

The displacement D is denoted by the letter T in tons in the first columns; the speed M in nautical miles per hour in top line, and the table gives the corresponding horse power H. The horse power here means the actual power of 33,000 pounds lifted one foot per minute, and not nominal horse power, rated by the dimensions of the steam cylinders.

Description of Amsler's Planometer, as applied to Shipbuilding.

This very ingenious and useful instrument seems to be but little known among engineers and constructors. It is a very important instrument in the construction of ships, where it saves a great deal of time and calculations; by applying the planometer to the frame drawing of a ship, the displacement is obtained correctly with only one multiplication, in a few minutes.



The accompanying figure represents Amsler's Planometer in position to take the areas of the immersed cross-sections of a ship. The instrument rests on

three points, namely, A, C, and *c;* it has a hinge at H; the point C is stationary when the point P moves about; the wheel *c* turns in different directions, indicating the area described by P. The nature of the instrument is such that, when the point P moves from D via A to B, the wheel *c* indicates the area of the figure A, B, C, D; if P is moved further from B via E to D, the wheel *c* subtracts the area B, C, D, E, leaving indicated the area A B E D. The wheel *c*, with the assistance of a *vernier*, gives three figures in the reading, and the wheel *e* moved by a worm-screw gives the fourth figure; the instrument gives a nicety of four figures in the reading, which is sufficient for most practical purposes.

The planometers are always made so that the point P is to be moved with the sun. However irregular a plan-figure might be, the point P moved through the whole boundary, gives the area on the wheels *c* and *e*. The cross-section A, B, *b*, is obtained by moving P in the boundary from A via B, *b*, and back to A.

When it is desired to know the area of all the cross-sections, it is not necessary to read off every one of them, but continue to move through all the boundaries and the wheels will add up the whole to one sum, which, multiplied by 2 and the distance between the sections, gives the displacement; though care must be taken not to take the greatest section @ twice. Suppose all the areas of the figure before us is to be taken for the displacement: Move P from A to B *b* A, B *a* A, B E D A, further from A to 2 B A, 1 B A, and the wheels will show the total sum of half the sections.

Mr. Amsler, formerly a resident of Philadelphia, returned about a year ago to his native country, Switzerland, the only place where the planometer is now manufactured. It is sold by McAllister, Chestnut street, Philadelphia, and by Elliot Strand, London, where more complete descriptions of the instrument can be had.

For the Journal of the Franklin Institute.

Indian Method of Making Fire.

In the "History of the Manufacture of Instantaneous Light," in the December number of the *Journal*, Prof. Lyon Playfair states that "the savages of various countries found for themselves a means of getting a light which was far from instantaneous. I think that it would require much more dexterity than we can employ to demonstrate how a light may be got by rubbing together two pieces of wood."

Perhaps many of us have tried the experiment with the same success as the lecturer; and as I have never seen published the method by which it is accomplished, the following explanation may not be without interest to your readers:—

I have a pair of the sticks used by the Indians on the Northwest Coast of the United States for obtaining fire; have seen the same sticks in use to produce fire, and have myself produced fire therewith. Each is sixteen inches long; the thicker is three inches in circumference, and has been cut so that a section would give a rough ellipse with the

largest diameter one and one-eighth inch. The smaller is one and three-quarters of an inch in circumference. Both are crooked, just as they grew, and after depriving the smaller of its bark, it was whittled so that a section would give an irregular polygon; this was done for a good reason, as will be apparent. I cannot say what the wood is, but it presents an open network when examined in section; they are apparently of the same kind, but the smaller has more compactness, and shows signs of a slower growth. The Indians always select pieces with that difference. Both have been thoroughly roasted, and were carried carefully wrapped in skin, to prevent the absorbing of moisture; accompanying them is carried a bunch of the inner bark of the cedar, picked very fine and dried.

To use them, the larger has a shallow circular hollow, less than one-eighth of an inch in depth, made on its broad side, near one end, and a narrow groove or channel cut from this to the side; the smaller stick has one end made very slightly rounding. The Indian squats, holds the larger stick upon the ground with his bare feet, and places under the groove a small bunch of the bark fibre. The smaller stick is then held upright, the rounded end placed in the hollow of the larger stick, and with both hands at top and the stick between them, he commences to rapidly revolve it by rubbing the hands upon each other backward and forward, at the same time exerting pressure downward, by which his hands gradually slip down; he dexterously —and this is *the* point of success—runs his hands to the top and repeats the previous operation. A fine brown powder is soon produced by the attrition, and is carried along the side groove among the bark fibre. This powder is finally ignited, and the burning transmitted along the groove to the bunch of bark fibre, which is quickly seized by the operator and blown into a flame.

With the sticks in my possession I have seen them produce a flame in about one minute, and have frequently done so myself in three minutes. In eleven years' experience on the Western Coast, I never saw but this pair of sticks, when we were thrown among a tribe previously unacquainted with white men. The Indians generally used lucifer matches bought from the Hudson Bay Company or trading vessels.

GEORGE DAVIDSON.

Germantown, Pa., Jan. 18, 1863.

For the Journal of the Franklin Institute.

St. Elmo's Fire.

JOHN F. FRAZER, LL.D.

DEAR SIR—In accordance with your desire, I have the pleasure herewith to furnish you with an account of my close contact with "St. Elmo's Fire."

About sixteen years ago—being then traveling in Ireland—I left my hotel at Castlederg, County Donegal, to post it to Stranorlar. I started about 5 o'clock in the evening of a lowering and chilly November day. I traveled in a fancy or sporting vehicle known in

Europe as a "tax-cart"—driving a pair of horses tandem fashion, and attended by an hostler from the hotel. As it was yet daylight when we started, we did not light our lamps.

The night soon darkened, and a heavy bank of very dark clouds accumulated in the southwest. As suddenly as a peal of thunder, and almost as loud, a heavy squall burst on us, causing us to hold the horses at a stand still, and shield our faces from the fury of the blast and of the cutting hail that accompanied it.

After a few minutes the squall had so far abated as to permit us to look up. The first thing I observed on lifting my head, was the whip in the hostler's hand, covered with a pale flame, from the point to about twenty-five or thirty inches down the handle. Almost at the same instant I observed the rim of the hostler's hat, as also of my own, encircled with similar flames. An involuntary impulse led me to snatch the whip out of the hostler's hand, who, poor fellow, was completely paralyzed with terror, and drawing it through my hand, which was covered with a thick leather riding glove, the flame attached itself partly to the glove and blazed for a few seconds, till I brushed it off with the other hand. I then drew my fingers along the rim of my hat, where the flame continued. The fingers, in passing over it, extinguished it while passing, but it immediately re-appeared, although to a less extent than at first.

The flame appeared to blaze up from one to two inches from the whip handle, and had that peculiar lapping sound made by the flame of melted sulphur when blown upon. I did not perceive any peculiar odor, although such might have existed, as my attention was directed altogether to the strange, and, as I supposed, threatening phenomenon with which I was so suddenly brought into contact.

The road was a strange one to me, and it being night, I could not then observe the character of the country; but I subsequently traveled over the same road by day, and found the country to be bare, open, and somewhat hilly; no trees to speak of, and no bogs—at least none that I could discover on the line of road.

The character of the weather after the squall was rather tempestuous, with occasional flashes of lightning, although I did not observe any during the squall.

I am, dear sir, yours truly, GEORGE MILLIKEN.

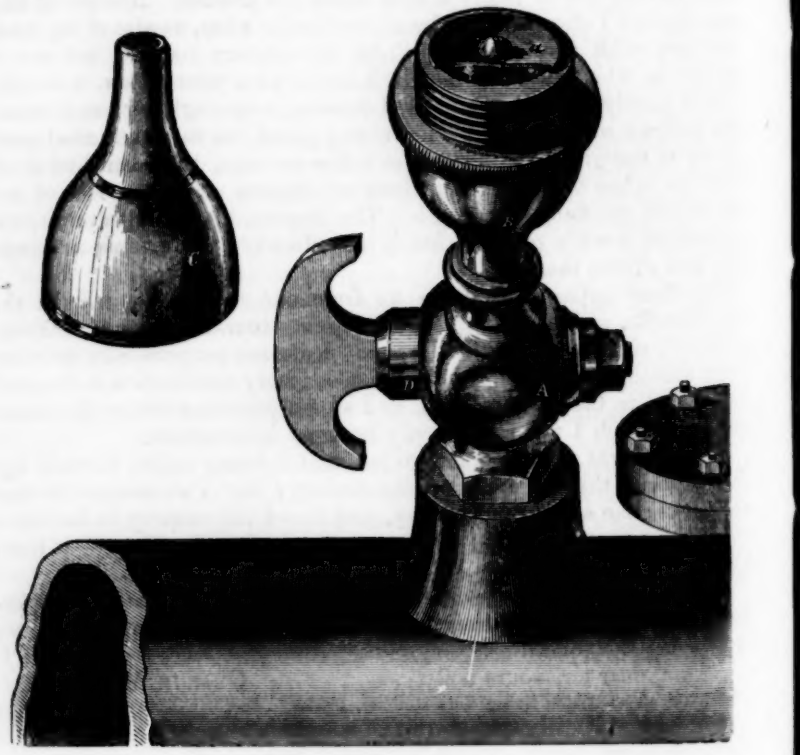
828 Arch street, Philadelphia, 24th October, 1862.

For the Journal of the Franklin Institute.

Description of an Improved Mode of Exhausting Air from Pumps. Patented by THOMAS SHAW, *of Philadelphia, Penna.*

The operation of Pumping is often impeded by the ingress of air, or the generation of vapor; an evil which becomes very great when feeding steam boilers under *high pressure.* The air or vapor alternately expands and contracts with the stroke of the pump, not permitting sufficient water to enter to lift up the check-valve. The ordinary method of exhausting this air or vapor is, by an ordinary stop-

cock; a very imperfect method, as the air is alternately drawn in and forced out with the stroke of the pump, and where the pump has to lift its water, is totally ineffectual. It is common for engineers to place their thumb over the orifice of the common faucet, and thus make a temporary valve to start the pump; or, by alternately turning on and off the stop-cock at each stroke of the pump. Although this imperfect method may answer for a single operation, there is no more cause for an engineer to become part of the valve arrangement of the pump, than for his becoming part of the valve gear of his engine, as was once the case, as the annexed engraving represents a simple device for the accomplishment of the above difficulties.



A represents an ordinary stop-cock, to which is attached a hemispherical top, B, having on its upper side a rubber valve, *a*, a portion of which is removed to expose the apertures beneath, which the said valve covers. The valve is protected and finished by screwing the cap, C, over the top of B. When the pump becomes inoperative because of air or vapor, the plug, D, of the stop-cock is turned, when the air or vapor makes its exit by lifting the valve, *a*, after which the valve closes and prevents any return of the same.

On Webster's Method of Preparing Oxygen Gas from a Mixture of Nitrate of Soda and Oxide of Zinc. *By* JOHN HENRY PEPPER, Esq., F. C. S., A. Inst. C. E., Professor of Chemistry, and Hon. Director of the Polytechnic Institution.

From the London Chemical News, No. 152.

The statement, that large quantities of oxygen gas could be quickly and easily procured from a mixture of one part, by weight, of nitrate of soda, and two parts of crude oxide of zinc, obtained from the (so-called) galvanizing zinc-pots or baths of Birmingham and other places, appeared so doubtful, that, prior to the introduction of the new process at the Polytechnic, I was induced to visit Mr. Webster and his co-patentee, Mr. John H. Porter, at Bent's wharf, Cannon Row, Westminster, in order to investigate practically the working of this new mode of making oxygen gas.

The apparatus, arranged for the manufacture of oxygen and other products, consists of a circular, portable, iron, fire-brick lined furnace, containing an inner, strong, cast-iron vessel, 10 inches in diameter, furnished with a cover and iron tube; into this is placed a second cylindrical iron pot or retort, of 7 ins. diameter, open at the top, and provided with an orifice at the base, temporarily stopped with a piece of sheet iron, so that, when the materials used are exhausted, the inner pot can be removed, and the contents easily knocked out with an iron bar; and as the product left after the disengagement of the gas is not allowed to fuse, and only becomes slightly coherent or pasty, this cylindrical form of retort, open top and bottom, and placed in an outer vessel of iron, which can be properly closed by a luted cover, answers remarkably well, and may be used by any intelligent workman. In connexion with the outer iron vessel is a 1½-inch iron pipe luted into a stoneware tube, forming part of, and leading to the bottom of a 30-gallon stoneware vessel, containing half a gallon of water (5 lbs.), and eight movable stoneware, colander-like shelves; upon these are placed 48 lbs. of residue, which have been taken out of the retort after a former experiment, *i. e.*, when the oxygen has been obtained from it. This residue, or *caput mortuum*, consisting (as will be noticed more particularly in another part of this paper) of oxide of zinc, caustic soda, nitre, nitrite and nitrate of soda, &c., is moistened with half a gallon of water, and carefully placed on the shelves, which are fitted in one after the other, commencing at the bottom of the vessel. The purifier, thus arranged, is furnished with a lid dropping into a water-joint, and the whole connected with a sheet iron gasometer, painted inside and out, and having a sectional area of 28·2744 feet, making the cubical contents per vertical inch 2·3562 c. i.

As the success of the process, so far as the maximum of oxygen is concerned, depends greatly on the thorough dryness of the materials used, 12 lbs. of nitrate of soda were dried on a hot plate forming the top of the circular iron furnace, and 24 lbs. of oxide of zinc were made red-hot in the retort; the loss of weight by this method of drying was very slight, and did not exceed an ounce or so in either case.

Ten pounds of the dry and warm nitrate of soda, and 20 lbs. of the dry and warm oxide of zinc, were then roughly mixed together in an iron tray, and dropped through an iron funnel into the inner red-hot retort, which could be easily lifted in or out of the exterior one by means of a chain and little crane attached to the furnace.

The cover, provided with a hole at the top, was then luted on with a mixture of Stourbridge clay and sand, and in about a minute or so the nitrate of soda gave off oxygen, colored with the orange-red fumes of nitrous acid: the top aperture was now closed, and the connexion with the purifier and gasometer opened at 1·30 P. M.

The following columns show the rate at which the gas was made, although it is right to state that the gas comes over frequently much faster:—

Time.	Vertical Inches, equal to 2·3562 Cubic Feet.
1.30	
1.35	1·50
1.40	1·90
1.50	2 30
2.00	3·00
2.10	4·30
2.30	6·75
2 40	8·50
2.50	9 75
3.00	11·00
3.10	12·00
3.20	13 00
3.30	13·30
3.45	14 00
4.00	14 30

2·3562 × 14 vertical inches = 32·968 cub. feet.

Directly the gas ceased to come over, the valve in connexion with the gasometer was turned off, and the inner retort being lifted out with the contents (the residue or *caput mortuum* already mentioned), and weighed, was found to have lost 5·5 lbs. After knocking out the residue, the retort was again quickly charged, at 4h. 5m. P. M., with a fresh mixture of 10 lbs. nitrate of soda, and 20 lbs. of oxide of zinc, which gave off the whole of the gas by 6h. 30m. P. M.

The gas amounted to 14·3 vertical inches—

$$14{\cdot}3 \times 2{\cdot}3562 = 33{\cdot}69 \text{ cubic feet},$$

and the loss of weight of the materials used was again found to be 5·5 lbs. The residue in the purifier having now been used for these two charges, was taken out, and it weighed 2 lbs. heavier than before, in consequence of its having absorbed nitric acid. The residue was then digested with the whole of the weak nitric acid which had been absorbed by the half-gallon of water placed at the bottom of the purifier (the whole weight of the acid being about 11 lbs.), and when perfectly dried and warm it weighed 48 lbs. It was then placed in the retort and lost 4 lbs., producing (according to Mr. Webster, who watched the operation to the end) 28 cubic feet of gas—thus showing that when 50 lbs. of refuse material out of the retort are used to purify the gas from 20 lbs. of nitrate of soda, the nitric acid obtained during the process is retained, partly by the solid substance, and

partly by the water in the purifier, and that, if the whole is then mixed, digested, dried, and subsequently heated in the retort, it will give out almost as much gas (28 cubic feet) as 10 lbs. of fresh nitrate of soda (33 cubic feet).

The 50 lbs. of residue were procured after heating a mixture of 20 lbs. of nitrate of soda and 40 lbs. crude oxide of zinc; so that the quantity of gas obtained by this plan from 20 lbs. of nitrate of soda, and using the nitric acid, amounts to—

	Cubic feet.
1st charge of 10 lbs. nitrate of soda and 20 lbs. crude oxide of zinc, .	32·986
2d ditto, ditto, ...	33·69
3d. Material out of purifier, after being used to absorb the nitric acid produced from Nos. 1 and 2, ...	28·00
Total cubic feet, ...	94·676

Theoretically, and supposing the 20 lbs. of nitrate of soda were chemically pure, and decomposed into oxygen and nitrogen, leaving a residue of soda, the loss should be 12·82 lbs.; the loss was, however, $5{\cdot}5 \times 2 = 11$ lbs. The nitrate of soda used was the ordinary commercial article, and contains $2\frac{1}{4}$ per cent. of chloride of sodium.

The gas obtained from the nitrate of soda and oxide of zinc was analyzed by the phosphorous method, and also by the usual hydrogen mixture fired by the electric spark in Ure's syphon eudiometer, and gave, as the mean of several experiments, 59 volumes per cent. of oxygen gas, and 41 volumes per cent. of nitrogen.

94·676 cubic feet of gas, therefore, contain—

	lbs.	oz.
55·858 cubic feet of oxygen* =	4	11
38·818 cubic feet of nitrogen =	2	13
Nitric acid and loss	3	8
	11	0

The nitric acid appears to be formed during the first stage of the process, when the materials thrown into the red-hot retort are comparatively cold, and evolve nitrous acid NO_3, and oxygen; these gases, in the presence of the moisture of the purifier, form nitric acid, and it is very likely that when a second and smaller red-hot iron vessel, containing oxide of zinc, or, still better, oxide of copper, is connected with the first iron retort, any acid produced during the process would be decomposed perfectly by the second red-hot surface, and, even if nitrate of zinc or copper were formed, it would be ultimately decomposed into nitrogen, oxygen, and oxide of copper. The experiment again, twice repeated, afforded nearly the same results:—

Experiments.	Nitrate of Soda.	Oxide of Zinc.	Loss.	Cubic feet of Gas.
No. 1,	10 lbs.	20 lbs.	5·25	37
No. 2,	10 "	20 "	5·25	32
2	20 lbs.	40 lbs.	10·50	69

In order to ascertain how often the same 20 lbs. of oxide of zinc could be used with separate additions of 10 lb. charges of nitrate of

* Weight of a cubic foot of oxygen, at a temperature of 60°, barometer 30 inches, . . . Grains. 590·8
Weight of a cubic foot of nitrogen, at same temperature and pressure, ... 517·7

soda, three experiments were tried, as tabulated below, it being understood that the second 10 lbs. was not added until the first had evolved its gas, and so on with the third 10 lbs.

Nitrate of Soda.	Oxide of Zinc.	Residue.	Loss.	Gas. Cubic feet.	Nitric Acid in solid contents of purifier 56 lbs.	Nitric Acid absorbed by water in purifier.
10	20	25·5	4·5	49.47	2 lbs.	3lb. + water 5
10	—	30 0	5·5	47·12	increase in	total 8lbs.
10	—	36·25	3.75	47·12	weight.	Sp. gr. 1·136
30	20	36 25	13·75	143·71	2 lbs.	8lbs. s.g. 1·136

These experiments were performed between 1 P. M. and 10 P. M., and it is evident that there is a great increase of gas, and a reduced proportion of nitric acid. It may be noticed as a proof the rapidity with which oxygen is prepared by this process, that with a small apparatus only capable of containing the three charges above mentioned, it produced 143·71 cubic feet of gas (containing 59 per cent. of oxygen) in nine hours, or nearly 16 cubic feet per hour.

If the apparatus had been large enough to contain more materials, there is no doubt that the same 20 lbs. of oxide of zinc would have done with one or two more separate 10 lb. charges of nitrate of soda.

The oxide of zinc probably acts mechanically (like oxide of manganese with chlorate of potash), and also chemically, as a carrier of nitric acid. When the nitrate of soda is heated, it gives off nitric acid, which is probably taken up by the oxide of zinc, and again decomposed (as the temperature rises) into oxygen and nitrogen: and, as before stated, if a second small red-hot vessel, containing oxide of copper or zinc, was attached to the retort, the whole of the nitric acid would probably be decomposed, and an increased proportion of oxygen obtained.

In order to form some notion of the value of the gas as a means of increasing artificial light, a peculiar shaped Bude Light burner, consuming coal-gas instead of oil, was experimented with.

The burner, with oxygen admitted to the centre of the flame, consumed, according to an experimental meter made by Brown and Bischoff, 4·2 cubic feet of coal gas, and 5·3 cubic feet of the oxygen gas per hour, and produced a light equal to 36·7 Parliamentary candles, consuming 120 grains per hour.

The same quantity of coal gas, per hour, burnt in a 36-hole Argand burner, with a chimney 9½ inches high, gave a light equal to 10·1 candles.

The light obtained from the coal gas and oxygen was exceedingly bright and white, both gas and candle-light looking yellow by the side of it.

The cost of the coal gas alone, to produce the same light, would be about equal to that of the extra oxygen used; but the purity of the light, and the saving of gas burners and fittings, by using oxygen and coal gas, increase the value of the combined arrangement.

To ascertain the composition of the residuum, weighing 36 lbs. 4 oz. (left in the retort after the three experiments, in which the same oxide of zinc was used three times), it was digested with plenty of water, and the insoluble oxide of zinc separated by a calico filter, and this, when washed and dried, weighed 23 lbs. 12 oz.

The filtrate and washings, evaporated to dryness in an iron vessel, weighed 15 lbs. 4 oz., and a portion of this analyzed gave the following results:—

Insoluble matter, nearly all oxide of zinc	4·20
Oxide of zinc soluble in the soda	4·40
Water	15·00
Soda	37·00
Chloride of sodium	5·54
Nitrite of soda	5·15
Nitrate of soda	28·31
Loss	·40
	100·00

The 36 lbs. 4 oz. would, therefore, contain, according to this analysis (stating it in round numbers, and omitting fractions):—

	lbs.	oz.	lbs.	oz.
23 lbs. 12 oz. of oxide of zinc and alkali, less 10 oz. water			23	2
15 lbs. 4 oz. consisting of oxide of zinc	1	5		
" soda	5	10½		
" water	2	4		
" chloride sodium	0	13		
" nitrite of soda	0	12½		
" nitrate of soda	4	5		
Loss	0	2		
	15	4		
Less water	2	4		
	13	0 =	13	0
Loss			0	2
			36	4
13 lbs. 12 oz. gaseous matter lost by the 30 nitrate of soda, consisted of 143·71 cubic feet of gas, containing—				
83·36 cubic feet of oxygen gas			7	0½
60·36 " nitrogen gas			4	7
10 lbs. nitric acid, sp. gr. 1·136, containing 19·128 per cent. dry acid, (Ure's table)			1	14½
Loss*			0	6
			50	0

With respect to the cost of the oxygen gas prepared by Webster's process, it may be stated that, taking the commercial price of nitrate of soda to be £14 10s. per ton, and the crude oxide of zinc at £2 per ton, the value of 30 lbs. of nitrate of soda would be about 3s. 10d.,

* Probably not really a loss, but represented in the 2 lbs. of nitric acid absorbed by the solid matter in the purifier, which is, no doubt, of a higher quality than that absorbed by the 5 lbs. of water in the same purifier, and equal to 8 lbs., sp. gr. 1·136.

and that of the 20 lbs. oxide of zinc, 4d., making a total of 4s. 2d.; and the following table exhibits the probable value of the products:—

Materials— Cost of Materials.		Products.				
		Gas.	Soda.	Nitrate of Soda.	Nitric Acid.	Oxide of Zinc.
	s. d					
30 lbs. Nt. Soda	3 10	143·71 cubic ft. containing 83·36 of oxygen.	5 lbs. at 2d per lb. *	4 lbs. at 1½d. per lb. *	10 lbs. containing 2 lbs. stronger, at 6d. per lb.	20 lbs. at 4d.
20 lbs. Ox. Zinc	0 4					
50 lbs. . . .	4 2	1s. 6d.	10d.	6d.	1s. 0d.	4d.

On comparing the cost of this method with those of other sources of oxygen gas, it will be noticed that Webster's is the cheapest known process, if the products can all be realized. Monsieur Deville calculates the cost of oxygen, obtained from various substances, as follows:—

		Fr.	s.	d.
One cubic metre (equal to 35·317 cubic feet):				
"	from chlorate of potash . . .	10 00 =	8	4
"	" oxide of manganese . .	4 87 =	4	0¾
"	" sulphuric acid	1·00 =	0	10
"	" nitrate of soda, ox. of zinc . .		0	7½ 6-10
"	" do. rejecting all products . . .		1	9 7-10

The cheapness of Webster's process is so satisfactory, that it will probably be used at the Polytechnic, provided that the nitrogen mixed with the oxygen does not materially interfere with the brilliancy of the lime-light.

Additional Report on the above Process. By WILLIAM CROOKES.

By the kindness of the proprietors of the patent, I have been afforded an opportunity of critically examining every stage of the above process, and am, therefore, enabled, from personal observation and experiment, to endorse all the facts given by Mr. J. H. Pepper in this report. The gas is produced from materials of but trifling value, in large quantity, and by an operation requiring no skilled superintendence whatever. At first sight it would seem that the proportion of nitrogen present with the oxygen would tend to render the gas of only slight commercial value. A little consideration will, however, show that this is not necessarily the case. Although pure oxygen is invaluable in the laboratory, and at the lecture-table, its employment in an undiluted form would be impracticable in ordinary metallurgical operations on a large scale, as the intensity of its action would very soon rise to such a degree of violence as to reduce flux, fuel, metal, and furnace into one chaotic liquid mass. It is, indeed, very doubtful whether the mixed gas which is obtained in such abundance under this patent, is not as strong as could be employed in most manufacturing operations without serious damage to the furnaces and crucibles used.

* A chemical manufacturer would separate, by crystallization, the greater part of the nitrite, nitrates, and chloride of sodium from the caustic soda.

The only case in which it is likely a purer gas would be required, is in the metallurgy of the more refractory platinum metals. The intensity of the "lime-light" produced with this mixture is necessarily inferior to that obtained with pure oxygen, but it is abundantly sufficient for all ordinary purposes of illumination, and far better than could be anticipated from the composition of the gas. Indeed, it is only by comparing the two lights simultaneously, side by side, that the difference of intensity becomes apparent.

The Electric Lamp in Lighthouses.

From the London Athenæum, Nov. 1862.

For the last five or six years the maritime world has been waiting with some anxiety for the termination of certain experiments respecting the employment of the electric light as a beacon. These experiments are well nigh concluded, and the question whether the old oil-lamp is to be superseded by the electric lamp, will be speedily determined.

Early in 1857, experiments were made on the subject at Blackwall and Woolwich by Prof. Faraday and Prof. Holmes, and subsequently the latter was requested by the Elder Brethren of the Trinity House to prepare a plan for employing the new light. This plan was submitted to Prof. Faraday, who reported favorably upon it, and the result was that the Trinity Board sanctioned the establishment of an electrical apparatus in the South Foreland Upper Lighthouse. This apparatus consisted of an accumulation of powerful magnets and iron cores with surrounding coils, accurately arranged, so that when the associated cores were revolving, they sent all their currents into one common channel, from whence they were conveyed to the lantern by conducting wires, and there produced the electric light. There was no consumption of material or energy, other than that of the burning fuel required at the steam engines to produce motion.

A trial of the light began in the lighthouse on the 8th of December, 1858; but as the apparatus was imperfect in some points, and the results unsatisfactory, the lighting by the apparatus was suspended for awhile, that the defects might be remedied. The lighting was renewed in March, 1859, and during the following month it was carefully examined by Prof. Faraday. In his subsequent Report to the Trinity Board, after describing very fully the observations he made at sea, and the various experiments by which he tested the power of the light, he states his opinion that Prof. Holmes had practically established the fitness and sufficiency of the magneto-electric light for lighthouse purposes, so far as its nature and management are concerned; that the light produced was powerful beyond any other that he had seen so applied, that its regularity in the lantern was great, and its management easy. Ten months after he had thus expressed his approval of the experiment, he again visited the light, and found it of the same character as when he had last seen it. It was gene-

rally very steady, but with slight interruptions now and then from iron in the carbons. He found that it had a tendency to sudden and spontaneous extinction, arising either from the breaking off of the end of the carbon, or from some disarrangement in the fine mechanical work of the lamp. This happened three or four times every night; and being once extinguished, the lamp did not relight of itself. The slightest touch of the keeper's hand, however, was enough to restore the light; but the liability to temporary extinction occasioned an anxious watchfulness on the part of the attendant, who was constrained on this account to stay in the lantern continually. The light had never been stopped by any deficiency of action in the machine-room.

The appointed time during which the magneto-electric light was to be placed under practical trial at the South Foreland having, early in 1860, come to an end, Prof. Faraday urged the Trinity House to authorize its application, either there or somewhere else, for a further and a longer period, stating that it had proved to be practical and manageable, and had supplied the means of putting into a lighthouse lantern, for six months or more, a source of illumination far surpassing in intensity and effect any other previously employed. Acting on this suggestion, the Trinity Board established an electric light at Dungeness. At this lighthouse it is placed in an optic apparatus constructed especially for it, which is only 16 inches in height and 14 inches in external diameter. The apparatus consists of six lenticular zones and seven reflecting zones; of the latter three are below and four above. At the South Foreland there was one electric lamp placed in the centre of a Fresnel optic apparatus. Here there are two of the new optic apparatus, placed one over the other in the axis of the lantern, and four electric lamps; for each apparatus two, only one lamp being used at a time. Mr. Holmes includes in his plan the use of all these lamps and apparatus, because of the facility of rapid change in the lamps and carbons, and they cause no alteration in the magneto-electric machines, wires, or engines, which are the same as were employed at the South Foreland.

Beside the electric apparatus, the light from which passes through the upper panes of the lantern, the original reflectors and their lamps are retained in place, so that they can be at once substituted for the electric light if any accident or failure should occur to the latter, and also may be used in conjunction *with* the electric light in a comparison of one with the other.

In one of his reports on the Dungeness light, written during the present year, Prof. Faraday mentions an interesting experiment. Arrangements were made on shore (Mr. Holmes being in charge of the light), by which observations could be taken at sea about five miles off, on the relative light of the electric lamp and the metallic reflectors with their Argand oil lamps. At the given distance the eye could not separate the two lights, but by the telescope they were distinguishable. The combined effect was a glorious light up to the five miles; then, if the electric light was extinguished, there was a great falling off in the effect; though after a few moments' rest to the eye,

it was seen that the oil lamps and reflectors were in their proper state. On the other hand, when the electric light was restored, the illumination became again perfect.

Then, whilst both were in action, the reflectors were shaded, and the electric light left alone; but the naked eye could see no sensible diminution; nor when the reflectors were returned into effectual use, could it see any sensible addition to the whole light power; though the telescope showed that the alteration in the lantern had taken place at the right time. Such was the power of the electric light that the addition or subtraction of the light of a fully effective set of reflectors, with their lamps, would not have been sensible to a mariner, however observant he might have been.

Prof. Faraday enumerates some points which are against, and others in favor of the light. In the first place, the simplicity of the present system is very great compared with that of the electric light: only two keepers are required to a lighthouse; they need possess no special knowledge; ordinary attention is all that is necessary; and thus failures of the light are almost impossible. In the new system, a second set of men will be required to attend the engines, and there must be amongst them one or more who understand the principle and construction of the lamp in the lantern, of the magneto-electric machines, the steam engines, and the condensers, and be able to make effectively the repairs necessary to the apparatus. In the next place, the expense of the new system must be large, compared with that of the present system. Other objections have been made, of which Prof. Faraday cannot see the force, namely, that the light is too bright—that it gives a false impression of the distance of the lighthouse—and that it blinds the eyes of the mariners to the perception of the lights on board vessels between it and them. These objections, he says, if they have any force, must be judged by mariners themselves.

The points in favor of the magneto-electric light are strong and clear in relation to the increase of light. In cases where the light is from lamp-flames fed with oil, no increase of light at or near the focus or foci of the apparatus is possible beyond a certain degree, because of the size of the flames; but in the electric lamp any amount of light may be accumulated at the focus and sent abroad, at of course an increased expense. In consequence of the evolution of the light in so limited a focal space, it may be directed seaward, diverging either more or less, or in a vertical or horizontal direction, at pleasure, with the utmost facility. The enormous shadow under the light produced by the oil-flame burner, which absorbs and renders useless the descending rays to a very large extent, does not occur in the magneto-electric lamp; all the light proceeding in that direction is turned to account; and the optical part of the arrangement, whether dioptric or reflecting, might be very small in comparison with those in ordinary use.

With reference to the final experiment now taking place at Dungeness, though Prof. Faraday thinks that many changes might be made in the size, arrangement, and adjustment of the optic apparatus, he reserves these points for longer and future consideration, aided by the instruction that will arise from the results of experience.

Use of the Balloon for Scientific Purposes.

From the London Athenæum, Sept., 1862.

In Mr. Glaisher's hands the balloon is restored to its old rank of a philosophical agent. Gay-Lussac has only shown the men of science how to use the balloon for scientific purposes; and considering how much has been done in the way of scaling peaks for the same science, it is surprising that the balloon has not been more largely used. But Mr. Glaisher, by his successive ascents, is adding largely to our knowledge of the higher regions of the atmosphere. Speaking of his own personal feelings in his last ascent, he says—"When we attained the height of two miles, at 1 h. 21 m., the temperature had fallen to the freezing point; we were three miles high at 1 h. 28 m., with a temperature of 18°; at 1 h. 39 m. we had reached four miles, and the temperature was 8°; in ten minutes more we had reached the fifth mile, and the temperature of the air had passed below zero, and there read minus 2°; at this point no dew was observed on Regnault's hygrometer when cooled down to minus 30°. Up to this time I had taken the observations with comfort. I had experienced no difficulty in breathing, while Mr. Coxwell, in consequence of the necessary exertion he had to make, had breathed with difficulty for some time. At 1 h. 51 m. the barometer read 11·05 inches, but which requires a subtractive correction of 0·25 inch, as found by comparison with Lord Wrottesley's standard barometer just before starting, both by his Lordship and myself, which would reduce it to 10·8 inches, or at a height of about 5¼ miles. I read the dry bulb as minus 5°; in endeavoring to read the wet bulb I could not see the column of mercury. I rubbed my eyes, then took a lens, and also failed. I then tried to read the other instruments, and found I could not do so, nor could I see the hands of the watch. I asked Mr. Coxwell to help me, and he said he must go into the ring, and he would when he came down. I endeavored to reach some brandy, which was lying on the table at about the distance of a foot from my hand, and found myself unable to do so. My sight became more dim; I looked at the barometer and saw it between 10 and 11 inches, and tried to record it, but I was unable to write. I then saw it at 10 inches, still decreasing fast, and just noted it in my book; its true reading, therefore, was at this time about 9¾ inches, implying a height of about 5¾ miles, as a change of an inch in the reading of the barometer at this elevation takes place on a change of height of about 2500 feet. I felt I was losing all power, and endeavored to rouse myself by struggling and shaking. I attempted to speak, and found I had lost the power. I attempted to look at the barometer again; my head fell on one side. I struggled, and got it right, and it fell on the other, and finally fell backwards. My arm, which had been resting on the table, fell down by my side. I saw Mr. Coxwell dimly in the ring. It became more misty, and finally dark, and I sank unconsciously as in sleep; this must have been about 1 h. 54 m. I then heard Mr. Coxwell say, 'What is the temperature? Take an observation; now try.' But I could neither see, move, nor speak. I then heard him speak more

emphatically, 'Take an observation; now do try.' I shortly afterwards opened my eyes, saw the instruments and Mr. Coxwell very dimly, and soon saw clearly, and said to Mr. Coxwell, 'I have been insensible;' and he, replied, 'You have, and I nearly.' I recovered quickly, and Mr. Coxwell said, 'I have lost the use of my hands; give me some brandy to bathe them.' His hands were nearly black. I saw the temperature was still below zero, and the barometer reading 11 inches, but increasing quickly. I resumed my observations at 2 h. 7 m., recording the barometer reading 11·53 inches, and the temperature minus 2°. I then found that the water in the vessel supplying the wet bulb thermometer, which I had by frequent disturbances kept from freezing, was one solid mass of ice. Mr. Coxwell then told me that while in the ring he felt it piercingly cold, that hoar frost was all round the neck of the balloon, and on attempting to leave the ring he found his hands frozen, and he got down how he could; that he found me motionless, with a quiet and placid expression on the countenance. He spoke to me without eliciting a reply, and found I was insensible. He then said he felt insensibility was coming over himself; that he became anxious to open the valve; that his hands failed him; and that he seized the line between his teeth, and pulled the valve open until the balloon took a turn downwards. This act is quite characteristic of Mr. Coxwell. I have never yet seen him without a ready means of meeting every difficulty as it has arisen with a cool self-possession that has always left my mind perfectly easy, and given to me every confidence in his judgment in the management of so large a balloon. On asking Mr. Coxwell whether he had noticed the temperature, he said he could not, as the faces of the instruments were all towards me; but that he had noticed that the centre of the aneroid barometer, its blue hand, and a rope attached to the car were in the same straight line. If so, the reading must have been between 7 and 8 inches. A height of six miles and a half corresponds to 8 inches. A delicate self-registering *minimum* thermometer reads minus 12°; but unfortunately I did not read it until I was out of the car, and I cannot say that its index was not disturbed. On descending, when the temperature rose to 17° it was remarked as warm, and at 24° it was noted as very warm. The temperature then gradually increased to 57½° on reaching the earth. It was remarked that the sand was quite warm to the hand, and steam issued from it when it was discharged. Six pigeons were taken up. One was thrown out at the height of three miles; it extended its wings and dropped as a piece of paper. A second, at four miles, flew vigorously round and round, apparently taking a great dip each time. A third was thrown out between four and five miles, and it fell downwards. A fourth was thrown at four miles when we were descending; it flew in a circle, and shortly after alighted on top of the balloon. The two remaining pigeons were brought down to the ground; one was found to be dead, and the other (a carrier) had attached to its neck a note. It would not, however, leave, and when jerked off the finger returned to the hand. After a quarter of an hour it began to peck at

a piece of riband encircling its neck, and I then jerked it off my finger, and it flew round two or three times with vigor, and finally towards Wolverhampton. Not one, however, had returned there when I left on the afternoon of the 6th. It would seem from this ascent that five miles from the earth is very nearly the limit of human existence. It is possible, as the effect of each high ascent upon myself has been different, that on another occasion I might be able to go higher, and it is possible that some persons may be able to exist with less air and bear a greater degree of cold; but still I think that prudence would say to all, whenever the barometer reading falls as low as 11 inches, open the valve at once; the increased information to be obtained is not commensurate with the increased risk."

British Weights and Measures.

From the London Chemical News, No. 150.

Omitting many specific anomalies, we have no less than ten different systems of weights and measures, most of them established by law:—1. Grain, computed decimally, used for scientific purposes; 2. Troy weight, under 5 Geo. 4, c. 74, and 18 & 19 Vict., c. 72; 3. Troy ounce, with decimal multiples and divisions, called bullion weights, under 16 & 17 Vict., c. 29; 4. Bankers' weights, to weigh 10, 20, 30, 50, 100, and 200 sovereigns; 5. Apothecaries' weight; 6. Diamond weights and pearl weights, including carats; 7. Avoirdupois weight, under 5 Geo. 4, c. 74, and 18 & 19 Vict., c. 72; 8. Weights for hay and straw; 9. Wool weight, using as factors 2, 3, 7, 13, and their multiples; 10. Coal weights, decimal, under 1 & 2 Will. 4, c. 76, and 8 & 9 Vict., c. 101, Nos. 1, ·3, ·2, ·1, ·05, ·025. We have also, in occasional scientific use, the weights of the metric system. For measures of length, we have the ordinary inch, foot, and yard. We have, in cloth measure, yards, nails, and ells. There are four different sorts of ells. For nautical purposes, we have fathoms, knots, leagues, and geographical miles differing from the common mile. The fathom of a man-of-war is 6 feet; of a merchant vessel, 5½ feet; of a fishing-smack, 5 feet. We have also the Scotch and Irish mile, and the Scotch and Irish acre. There are several sorts of acres in the United Kingdom, and there are a great variety of roods. We have, in almost every trade, measures of length especially used in those trades: for the measurement of horses we have the hand; shoemakers use sizes; and we are compelled to adopt gauges where the French use the *millimètre*. These gauges are entirely arbitrary. The custom of the trade is the only thing which would decide the question in case of dispute. For measures of capacity we have twenty different bushels; we can scarcely tell what the hogshead means: for ale, it is 54 gallons; for wine, 63. Pipes of wine vary in many ways; each sort of wine seems to claim the privilege of a different sort of pipe. For measures of weight we have about ten different stones: a stone of wool at Darlington is 18 lbs.; a stone of flax at Downpatrick is 24 lbs.; a stone of flax at Belfast is only 16¾ lbs.; but it is also at Belfast 24½ lbs., having in

one place two values. The hundredweight may mean 100 lbs., 112 lbs., or 120 lbs. If you buy an ounce or pound of any thing, you must inquire if it belongs to Dutch, troy, or avoirdupois weight.—*Report of the Select Committee.*

Rapid Growth of Vegetables in High Latitudes.

From the Intellectual Observer, August, 1862.

In a valuable treatise on the vegetable productions of Norway, which has been published by Dr. Mueller, in connexion with the Norwegian department of the Exhibition, some extraordinary facts are related respecting the influence of the long duration of light, during the summer months, on the growth of vegetables in the higher latitudes in Norway. At seventy degrees N. it was found that ordinary peas grew at the rate of three and a half English inches in twenty-four hours for many days in summer, and that some of the cereals also grew as much as two and a half inches in the same time. Not only is the rapidity of growth affected by the constant presence of light, but those vegetable secretions which owe their existence to the influence of actinic force on the leaves, are also produced in far greater quantity than in more southern climates; hence the coloring matter and pigment cells are found in much greater quantity, and the tint of the colored parts of vegetables is consequently deeper. The same remark applies to the flavoring and odoriferous matters, so that the fruits of the north of Norway, though not equal in saccharine properties, are far more intense in flavor than those of the south.

Artificial Tourmalines. By JAMES W. YOUNG.

From the London Chemical News, No. 147.

SIR—In reply to your correspondent's inquiry relative to a method of forming "Herepath's Artificial Tourmaline," I beg to inform him that he will find the requisite information in the following extract from Bird and Brookes' Natural Philosophy, page 503:

"Dissolve 50 grains of disulphate of quinine in two fluid ounces of acetic acid, and two of proof spirit warmed to 130° F., in a very wide-mouthed flask or glass beaker; then slowly add 50 drops of a mixture of 40 grains of iodine in an ounce of rectified spirit; agitate the mixture, and then set it carefully aside for six hours, in an apartment maintained at a temperature of about 50° F. The utmost care must be taken to avoid any motion of the vessel; indeed, all accidental vibrations should be guarded against by suspending the vessel by a string, or by allowing it to rest on a mass of cotton wool. If, in six hours, the *large* laminæ of the salt have not formed, warm the fluid with a spirit-lamp, and when it has become clear, add a few drops of the solution of iodine in spirit. The large laminæ form on the top of the fluid, and should be removed carefully by gliding under one of them a circular piece of thin glass. The specimen should be drained by resting the edge of the glass on a piece of bibulous paper, but it must not

be touched, on account of its extreme fragility; if any small crystals adhere to its surface, they must be washed off by pouring over it a few drops of watery solution of iodine. When dry, the specimen should be placed for a few minutes under a bell-glass by the side of a watch-glass containing a few drops of tincture of iodine; and, lastly, a little very fluid Canada balsam should be dropped on it, and a thin glass cover applied without heat. Specimens may thus be obtained of extreme thinness, and half an inch in diameter or even larger, possessing scarcely the slightest color, and yet completely polarizing transmitted light.

Glasgow.

A New Vehicle for Paints.

M. Oudry, of Auteuil, has found that benzine and coal-oil are the best vehicles for paints of metallic basis (lead, zinc, &c.,) as they dry rapidly, have no smell after the first twenty-four hours, and present a very fine grain. He has also made a very superior bronze by pulverizing copper deposited galvanically.—*Cosmos.*

Disintegrated Black Lead.

From the London Intellectual Observer, August, 1862.

The chemically-disintegrated graphite of Mr. Brodie is a subject of great interest, as it affords a ready means of obtaining a chemically pure black lead, that by mechanical pressure can be aggregated into a solid mass, and employed for those purposes for which the best and most expensive plumbago has hitherto alone been applicable. The outline of the process may be thus stated; the impure plumbago is mingled with chlorate of potash, and then acted upon by a mixture of nitric and sulphuric acids; these not only give rise to the evolution of gaseous chlorine compounds, but also dissolve up and remove many of the impurities. The plumbago, thus obtained in a pure form, is washed and heated, the result of the combined mechanical and chemical action of these operations is, that the plumbago is so perfectly disintegrated as to be formed into light floculi, which are capable of being blown away by the slightest current of air. In this condition they are readily condensed into solid blocks by pressure.

Application of the Spectroscope in the Arts.

The French metallurgists have found an ingenious and no doubt valuable application of the new discoveries as to the differences in the light from different substances when burning. In the new process for making steel, there is a certain point in the operation at which the cover of the furnace should be lowered. A certain time is required for the escape of the gases which would injure the qualities of the steel, but after they have all escaped, should the furnace throat be left open, the action would be in another way not less injurious to

the steel. It is now proposed to determine the proper moment by observation of the flame by the spectroscope, and so soon as the flame shows the absence of the gases to be expelled, the cover is lowered upon the furnace. *Cosmos.*

New Explosive Compound.

From the London Artizan, Oct., 1862.

A new explosive powder, invented by Mr. Reynaud de Tret, appears destined to render great services to the working of mines in consequence of its low cost price. It is stated to be particularly applicable to the working of stone quarries. It is composed as follows:—Nitrate of soda, 52·5; residue of tan (after having been used in the tanning of hides), 27·5; pounded sulphur, 20·0; total, 100·0.

An Exhibition of Native Produce and Industry in Turkey.

From the London Builder, No. 1030.

The example of the International Exhibition seems not to have been lost on the Porte. A grand show of native produce and industry has been decided on, and will be held in Stamboul during the coming Ramazan. To secure the successful realization of this idea, special local delegates are to be at once appointed in all the principal districts of the empire, for the collection and classification of samples. These last will be forwarded to the capital free of all custom or other dues, and at the Government expense. As in London, sales of the articles exhibited will be allowed; and, in the event of their not being so disposed of, the Government will engage to buy all the smaller parcels. Prizes, in money or medals, will also be given to the successful exhibitors.—*Levant Herald.*

ROCEEDINGS OF THE BRITISH ASSOCIATION.

From the London Athenæum, Oct. 1862.

Section G.—Mechanical Science.

The President, Dr. W. Fairbairn, opened the proceedings with an address in which, after briefly alluding to the great advance made in the application of science to the useful arts during the last fifty years, he proceeded to advert to the progress and position of mechanical science as shown in the International Exhibition. A very casual glance at this exhibition, as compared with those of 1851 and 1855, shows with what energy the public mind has been at work; and though there is no new discovery of importance in mechanical science, yet the machines are more compact and better executed than at any previous exhibition, and a great deal is to be seen of a character both interesting and instructive. In land steam engines, the horizontal is rapidly supplanting the beam or vertical engine, and is applied not only with efficiency to manufacturing but also to agricultural purposes. In marine engines we are without rivals: we find in them beauty of execution, compact form and colossal dimensions, combined with a simplicity,

concentration of power, and precision of action never before equalled in this or any other country; and it must be a source of pride that this country, the first maritime nation in the world, should stand pre-eminently first as the leader of naval propulsion. In locomotives, if we are not in advance of other countries, we are not behind them; though both France and Germany exhibit splendid specimens of engines. There is, however, in this country a greater simplicity of construction, greater compactness of form, and clearer conceptions in working out the details. With regard to machines, and tools, the creators of machines, at no period before has such an exhibition been seen. Some of the tools, such as the turning, planing, boring and slotting machines, are of a very high order; and the tool machines for the manufacture of fire-arms, shells, rockets, &c., are of such a character as to render all the operations, however minute, perfectly automatic, with an accuracy of repetition that leaves the finished articles identical with every other article from the same machine. Such, indeed, is the perfection of the tool system, that in almost every case we may calculate on no deviation beyond the one-thousandth of an inch.—The speaker then proceeded to notice the spool machine for winding sewing thread on bobbins, the paper-bag making machine, and the riband saw machine. He then adverted to the changes in the construction of ordnance, and in the art of defence. For a time it was considered that ships plated with iron 4½ inches thick were invulnerable to shot or shell; and this opinion was acted upon in this country, in France, and in America. Our Government experiments have to a great extent dispelled these notions. It has been proved that a smooth bored Armstrong gun with a 150-lb. spherical shot can pierce a 4½ inch plate and 18 inches of teak. In fact it has been proved by experiments that no vessel yet constructed is able to carry armor-plates of sufficient thickness to resist such powerful ordnance as has been brought against it. The best description of iron has been sought for and obtained, and the balance of power had, however, remained in favor of the gun,—but with this qualification, that the gun had to sustain an explosive force of powder equivalent to one-third the weight of the shot—a charge which the gun was unable to bear. Under ordinary circumstances, with the usual charge of one-eighth the weight of the shot, it might be reasonably inferred that the balance of strength was on the side of the plate, and the guns of such heavy calibre were insufficient in strength to sustain these enormous charges of powder. The results, too, had only been produced by these heavy charges at short distances. It was determined to try the effect of the Horsfall gun, 22 tons weight, with a charge of 75 lbs. of powder and a 300-lb. shot, against the Warrior target of 4½ iron and 18 inches teak: the result was, the penetration of the mass with a huge opening into the target of upwards of 2 feet in diameter. This experiment would not apply to ships of war which could not carry ordnance of such immense weight, but was applicable to the case of forts, from which an enemy's ship might be struck at the distance of 1000 yards.—Passing from the Horsfall gun, Mr. Fairbairn related the late experiments with the

Whitworth gun. There had been very early established the distinction between the penetrating powers of solid shot and shell, the shell invariably failing to penetrate even a moderately thick plate of iron, and it was concluded that a comparatively thin plate was a sufficient defence against it: 2½ inches, and even 2 inches, were considered a sufficient thickness. The late experiments with a Whitworth gun and flat-fronted hardened shells had, however, dispelled these notions. The 12-pounder at 200 yards sent these shells through a 2 inch plate backed with a foot of timber. It had been suggested that a more powerful armor might be constructed by dividing the armor into two plates, each half of two inches thickness, and these plates separated by a certain space; the theory being that, though the first might be pierced, yet the force of the shell would be so deadened that the second plate would stop it. The Whitworth 70-pounder was tried against a target on this principle. A strong oak frame, armed with a 4-inch plate, was attached to a second plate of 2 inches thick, an interval of two or three feet being left between them. The shell with only 12 lbs. of powder pierced the outer side of the target completely, oak and iron together, after which it burst inside the frame and shattered it to pieces. From this it was clear that 4 inches of solid iron and 9 inches of wood was no protection against such a gun, and that no gun-boat, such as those on American waters, was proof against such a weapon. In point of fact, Mr. Whitworth, with a rifled gun lighter than a 68-pounder, could destroy them with his steel-hardened shells at a distance of 1500 or 2000 yards. A further experiment with a larger Whitworth gun, a 120-pounder, at a distance of 600 yards, proved that the sides of the *Warrior* are no longer shell-proof. A 130-lb. solid shot, with a charge of 23 lbs. of powder, went through the 4½-inch plate, and lodged in the wood behind it. A shell of the same weight, with a charge of 25 lbs. of powder, penetrated the armor plate and exploded, tearing the wood backing, and lodging in the opposite side. From these experiments, Mr. Fairbairn inferred that the victory is on the side of the gun, and that it may be difficult, under such powerful odds, to construct ships of sufficient power to prevent their destruction by the entrance of shells.

Mr. J. Nasmyth then described his "Improved Form of Link Motion."—There were many contrivances for effecting the same purpose as the "link" motion; but the latter, the invention of a mechanic in the employ of the Stephensons, had superseded all others. Mr. Nasmyth showed how, by his modification of it, a greater simplicity of construction was obtained, and a greater freedom from the evils which the wear and tear of the ordinary link motion produced. He had invented it in 1852, but it was little known. It had, however, been adopted with great success by Mr. Humphreys. It would be seen on the engine exhibited by that gentleman in the International Exhibition.

Mr. E. E. Allen read a paper "On the Importance of Economizing Fuel in Iron Plated Ships,"—pointing out that a great saving might be effected in the consumption of coals, by using a longer stroke engine.

Mr. Scott Russell said it was agreed that the short-stroke engine was wasteful of steam and fuel.

Dr. F. Grimaldi read a paper descriptive of a New Marine Boiler for generating Steam of High Pressure. His boiler was a cylindrical tubular boiler, with certain arrangements of radial tubes for taking up and conveying the steam, and made to rotate slowly in the furnace on its axis. The advantages claimed were, freedom from priming, smallness of space occupied, superheating the steam, and economy of fuel.

A discussion ensued, in which the President, Messrs. Appold, Scott Russell, Siemens, E. E. Allen, and Beardmore took part; the general tone of the discussion being favorable to the invention.

Mr. W. Thorold then read a paper "On the Failure of the Sluice in Fens, and on the Means of Securing such Sluices against a Similar Contingency."—The author described the circumstances attending the failure of the sluice, and pointed out that, in his opinion, the mode of preventing such an accident in future was the employment of double sluices, one behind the other, the water between the two being always kept locked in at a mean height between the water in the drain and that on the sea-side.

The discussion was adjourned till Monday, in order that the members should have an opportunity of previously seeing the place, to which an excursion would be made on Saturday.

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Mr. J. Oldham read the Report of the Committee appointed last year to make "Tidal Observations in the Humber." The observations were made at three places: New Holland, Hull Victoria Docks, and at Goole Docks. They were taken every five minutes at New Holland and at Goole, and every fifteen minutes at Hull Docks. The observations comprised 55 tides, and were taken at a period when little or no wind occurred to disturb the ordinary rise and fall. The results were carefully tabulated and presented to the Section. These observations fully bore out the statement made by Mr. Oldham at the Manchester Meeting of the Association, that at Hull, for three hours after the tide has attained to the 16-feet mark there is no more rise.

"On the Strains in the Interior of Beams and Tubular Bridges," by the Astronomer Royal.—The Astronomer Royal, after briefly adverting to the circumstance that he now addressed the Section in the same place in which more than thirty years previously he was accustomed (as Plumian Professor) to deliver lectures, sometimes on subjects analogous to this now before them, proceeded with the subject nearly in the following order. He had often desired to know (as probably many members of the Section had desired) what were the directions and magnitudes of the crumpling or stretching actions in the sides of our great tubular bridges, and had referred to several books on related subjects, but derived no assistance from them. After several attempts, he had at length succeeded in constructing a satisfactory theory. It was first necessary to acquire an idea of the measure of compressing or tensile forces in planes (the whole investigation as regarded bridges,

being confined to their vertical planes), and this would be the length of the ribbon of metal whose weight acting on any limited space would produce the compression or tension sustained by that limited space. Next, it was necessary to find according to what law the effect of the force varies when its direction varies (as, for instance, what is the tendency to tear open a fissure, if the direction of a tensile force rotates in the plane of the metal); and he found it proportional to the square of cosine of the angle which the direction of the force makes with the normal to the line sustaining the action. Using this fundamental theorem, he was able to show that the most complicated combination of forces might be reduced to the combination of two forces at right angles to each other; both forces being compressive, or both tensile, or one compressive and the other tensile. The problem, therefore, in any given case of a beam, would be, to find the magnitudes of two forces and the direction of one (three elements in all) at every point of the beam. Conceive, then, a beam to be divided (optically, not mechanically) into two parts, by a curved line in its vertical plane, extending from the lower to the upper edge, and consider the equilibrium of the more advanced part of the beam. The forces which act on it are,—the compressing or tensile forces acting over the imaginary curved line, the weight of the different portions of the more advanced part of the beam, and the reaction of supports in that part of the beam. It is soon found that the symbols for the three elements above mentioned become combined in forms which render it convenient to use three new symbols for their combinations, including also the weight of the advanced part of the beam. Putting L, M, O, for these symbols, R for a vertical reaction at the distance h in the direction of x (x horizontal), the three equations of equilibrium are)—

$$\text{(Equation for forces in } x\text{)}, \int dx.\ (\mathrm{L}p + \mathrm{M}) = o;$$

$$\text{(Equation for forces in } y\text{)}, \int dx.\ (\mathrm{M}p + \mathrm{O}) - \mathrm{R} = o;$$

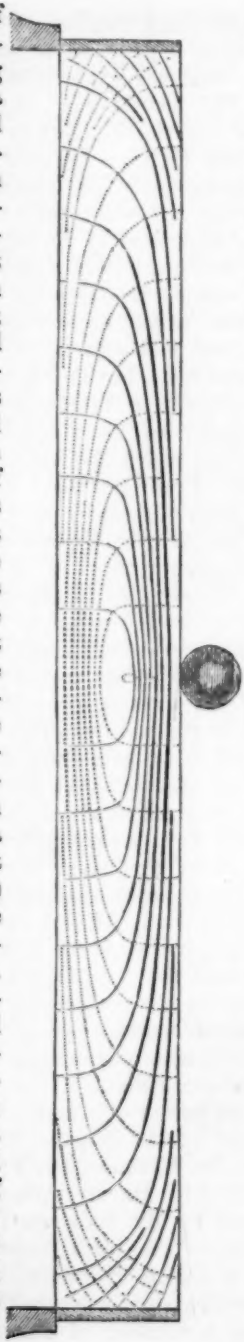
$$\text{(Equation of momenta)}, \int dx. \left\{ y\ (\mathrm{L}p + \mathrm{M}) + x\ (\mathrm{M}p + \mathrm{O}) \right\} - \mathrm{R}h = o:$$

p being put for $\frac{dy}{dx}$.

The equations in this form are somewhat unmanageable; but the following fortunate idea removed all difficulty:—Since the equations are true for any curve, and are, therefore, true (*mutatis mutandis*) for any curve near another, the difference in the equations produced by stepping from one curve to another will be $= o$. This is evidently a case for application of the process of the Calculus of Variations. On applying it, the first equation gives $\frac{d\mathrm{M}}{dy} - \frac{d\mathrm{L}}{dx} = o$; the second gives $\frac{d\mathrm{O}}{dy} - \frac{d\mathrm{M}}{dx} = o$: the third gives an equation, then, identically true. From this it follows, immediately, that the three quantities, L, M, O,

may thus be represented, in terms of one function, F of x and y, and of arbitrary functions, ϕ and ψ; $L = \frac{d^2 F}{dy^2} + \varphi(y)$, $M = \frac{d^2 F}{dx dy}$, $O = \frac{d^2 F}{dx^2} + \psi(x)$. Now suppose F is so chosen that the equations may be satisfied without $\phi(y)$ and $\psi(x)$; then it is evident that $\phi(y)$ and $\psi(x)$; will satisfy the equations without their last constant terms: they may, therefore, be multiplied or aggregated in any degree; and upon viewing the way in which they enter into the equations, they are simple forces —one in the direction of x, and the other in the direction of y. It is plain therefore, that these are accidental forces in the interior of the metal, such as are produced by injudicious casting of fusible metal, or injudicious union of malleable metal; they are not subjects for present contemplation and are to be omitted. Omitting them, and substituting the simpler expressions for L, M, O, in the equations, every part becomes integrable *per se;* and the integrated equations become the following (in which the values for the first part of the curve, where $x = z$, $y = o$, are to be subtracted from those for the extremity of the curve at the upper corner of the end of the beam, where $x = 2r$, $y = s$): $\frac{dF}{dy} = o$, $\frac{dF}{dx} = R$, $y\frac{dF}{dy} + x\frac{dF}{dx} - F = Rh$: equations of remarkable simplicity. Various considerations show that the expressions for the forces will contain only integral powers of x and y. Assuming, then, a form for F, with indeterminate co-efficients, several relations are given by these equations. Still, it is necessary to find other considerations, in each special case, which will produce due limitation of the extreme generality of form. For this purpose reference is made to the theorems of ordinary mechanics, by which, in the case of a strained elastic beam, the horizontal disruptive force is found. This force is the equivalent of $-L$ or $-\frac{d^2 F}{dy^2}$. This consideration in every case is sufficient; it being always necessary to ascertain that the three equations are satisfied. F being thus completely determined, and L, M, O, being found, the original three elements (two forces and the direction of one) are obtained numerically without difficulty. As a specimen of the forms assumed by F; in the instance of a beam whose length is $2r$ and depth s, supported on two piers, $F = \frac{1}{2s^3}(x^2 - 2rx)(3sy^2 - 2y^3)$. It was pointed out that the state of the end of the beam in this instance required special consideration. In other vertical sections of the beam, a strain on one side is met by a nearly equal strain on the other side of the section; but at the end, though the forces are considerable, there is no antagonistic force. On resolving the forces it is found that the horizontal force $= o$; but the vertical force is considerable, being aggregated by successive vertical pressures from the top to the bottom, where this

sum at last amounts to half the weight of the beam. This gives rise to the necessity, recognised by engineers, of inserting a strong vertical frame in the end of a tubular bridge. The Astronomer Royal then stated that he had applied the theory to the following cases:—1. A beam projecting from a wall; 2. A beam supported at both ends; 3. A beam supported at both ends, and carrying a weight on its centre; 4. A beam supported at both ends, and carrying an eccentric weight; together with two others to be mentioned shortly. Of the instance No. 3, he exhibited a large drawing, in which the strains and their directions have been computed for 231 points; and he called attention to the following special distributions of force:—The great longitudinal strains near the centre of the beam's length, but not in the centre of its depth; and the considerable inclined strains near its ends, of which there is little trace in the middle; as also to the circumstance that at the middle of the beam's depth the forces make angles of 45° with the horizon, throughout; and sensibly the same angles at the end of the beam. The Astronomer Royal then referred to the remarkable contrivance adopted in the junction of the tubular segments of the Britannia Bridge, in which (by raising the distant end of one segment at the time of union) the junction was so effected as to strain the middle of each segment upwards, thereby doubling the strength of the bridge. He pointed out that this contrivance introduces an additional term in the third equation, expressing the addition of a *moment*. He had applied the theory completely to the two cases: 5, where such strains are impressed on both ends of a tube; 6, where such a strain is impressed on only one end of a tube. The lines of strain are very much changed. In No. 5, the inclined strains, which in Nos. 2 and 3 are at the ends, are now advanced towards the middle: and the ends, as well as the middle, are principally affected



[Strains in the interior of a beam or tubular bridge, whose ends rest upon piers, and which supports, at the middle of its length, a weight equal to half the weight of the beam. The continuous curves indicate the direction of thrust or compression, and the interrupted curve or chain lines indicate the direction of pull or tension.]

by longitudinal strains. It was then pointed out that all these conclusions depend on an assumed physical principle, of which Mr. W. H. Barlow's experiments appear to suggest a slight modification. The Astronomer Royal concluded by addressing himself to Members of the University present with the remark, that in problems like this, applying to constructive mechanics, as well as in those applying to the system of the world, examples might be found illustrating the beauty and the power of mathematics, at least equal to those suggested by the ingenuity of examiners, and possessing that dignity which attaches to reality of application.

This communication gave rise to several comments.—Dr. Robinson stated that he had himself desired to investigate the subject mathematically, and had arrived at equations probably identical with those first found here, but had been unable to reduce them to a manageable form.—Professor Rankin had made some advance in the theory, and in particular had ascertained the law of aggregation of pressure in the end frames, which the Astronomer Royal recognised as agreeing with his own. Professor Rankin considered that a great step had been gained in the present communication, in showing that all the pressures might be made to depend on one function, F.—Mr. Fairbairn gave an interesting account of the way in which experiments had been carried on in reference to the then future construction of the Britannia Bridge, the models being loaded till they broke down in different ways, and being then strengthened in those parts and again tried. He recognised the conclusions of the theory as agreeing precisely with the results of the experiment.—Mr. Scott Russell also described the views which had guided him in planning the various parts of tubular bridges, which led to an according result.—On the suggestion of some Members of the Section, that the lines of strain bear some relation to the lines of polarization and dipolarization produced by strained glass, the Master of Trinity remarked that this view had been suggested many years ago by Sir David Brewster, and that it had been partly illustrated by experiments made in this very lecture-room.

Professor D. T. Ansted, M. A., read a paper "On Artificial Stones." In this paper the author described the various materials and contrivances used for the purpose of replacing stone where natural stone could not be advantageously procured. He described, in succession, terra cottas, cements, and siliceous stones, pointing out the character, properties, uses, advantages and disadvantages of each. He alluded to experiments made in the laboratory on the various methods suggested for preserving stone by a Section of the Committee recently appointed by the Board of Works in reference to the Palace of Westminster; Dr. Hoffman, Dr. Frankland, Mr. Abel and the author being members of it. During their investigations a remarkable material was submitted by Mr. Ransome for their consideration, and its discovery arose out of Ransome's method of preserving stone by effecting a deposit of silicate of lime within the substances of the absorbent stone, by saturating the surface with a solution of silicate of soda, and then applying a solution of chloride of calcium; thus producing a rapid

double decomposition, leaving an insoluble silicate of lime within the stone, and a soluble chloride of sodium, which could afterwards be removed by washing. To prove this, Mr. Ransome made small blocks of sand in moulds by means of silicate of soda, and then dipped them in chloride of calcium. The result was the formation, almost instantaneously, of a perfectly compact, hard, and to all appearance, a perfectly durable solid. Mr. Ransome at once adopted the process for the formation of an artificial stone which, the author of the paper considered, would combine the advantages and show some of the disadvantages of other artificial stones. Experience, however, can alone be the test of its durability. A specimen weighing two tons is shown in the International Exhibition, and the substance is used in the stations of the Metropolitan Railway. It is cheap, can be made on the spot of almost any rubbish or material, and of any form or size. Experiments made by Mr. Ransome show that, as compared with Portland stone or Caen stone, a bar with section 4 inches square and 8 inches long, between supports, sustained 2122 lbs. suspended midway between the supports, while similar bars of Portland and Caen stone broke respectively with 750 lbs. and 780 lbs. The adhesion of the stone is shown by weights suspended from a piece prepared to expose a sectional area of $5\frac{1}{2}$ inches. Caen stone separated at 768 lbs.; Bath, at 796 lbs.; Portland, at 1104 lbs.; Elland Edge, at 1874 lbs.; Ransome's, at 1980 lbs. A cube of 4 inches sustained 30 tons. Mr. Ransome showed the process to the Section by making several pieces in the presence of the Members and the process was also exhibited afterwards at the *Soirée* in the Guildhall.

Mr. R. W. Woolcombe then brought forward a paper "On Oblate Projectiles with Cycloidal Rotation contrasted with Cylindro-ogival Projectiles having Helical or Rifle Rotation."—The object of this paper was further to discuss the views of the author given in a paper read before the Royal Society in March last, entitled "An account of some Experiments with Eccentric Oblate Bodies and Disks as Projectiles," and to show the results of further experiments. Rifled cannon, it appears, cannot project heavy elongated shot with high initial velocity; and, except with the Whitworth flat-headed shot, the penetration of iron plates can only be effected by means of a high velocity. The author considers that, however well the helical or rifle method with cylindrical elongated shot may answer for small arms, yet that, when we wish to project great weights with great and sustained velocities, we shall succeed better if our mechanical arrangements were less antagonistic than the rifle principle to the great laws of nature as exhibited in the form, method of rotation and translation of the great natural projectiles, the planets. None of these are prolate bodies projected with helical rotation about their longest diameters and in the direction of their axes. The author states that he has found it practicable to project a body that, instead of being prolate, is more or less oblate; that, instead of having helical rotation at the *expense* of translation, has cylindrical rotation in *aid* of translation.

A projectile having a circular periphery in the line of motion in the gun leaves the bore as freely as a common round shot, and has the additional security for high initial velocity of windage less than for round shot of similar weight. The terminal velocity is also provided for by the oblateness, and by the axis of rotation being always transverse to and not in the plane of the trajectory. The gun has a similar transverse section to that of the projectile, the bore being straight and smooth. The projectile is a disk, and it should be *slightly* eccentric to make it rotate—so slight as to be little more than the inevitable eccentricity of every spherical projectile. The author then gave the results of some actual experiments with a gun and projectiles made on this principle. The gun was 20¼ inches long; the calibre long diameter 1⅞ inch, and short diameter ¾ inch. The shot weighed nearly 8 ounces, with a charge of 2¼ ounces, or ⅜ the weight of the shot; the penetration at 25 yards from an oak target was a mean of 11 inches, reckoning to the near side of the disk, and to the far side nearly 13 inches. The initial velocity measured by Haver's Electro-ballistic Apparatus, was 1487 feet per second. A comparison was made with a small brass gun, length of bore 34·625 inches, or nearly double the length of the author's gun in calibres. The mean calibre of the brass gun was 1·6 inch, the mean diameter of the round shot was 1·43 inch; and this gun, fired with a proportionate charge of powder, showed that the disk gun gave more than double the penetration of the brass gun, and an initial velocity of 1487 to 1091 of the latter. He thought that these remarkable experiments showed that the subject was worthy of further consideration.

Mr. Le Neve Foster read a paper communicated by Mr. C. Hart, "On Type Composing and Distributing Machines," in which the author described and pointed out the advantages of Mitchel's Machine, shown in the western annexe of the International Exhibition, and which was stated to be in successful operation in several printing establishments in this country and in the United States of America. The details are too complicated to be briefly described or made intelligible without the aid of diagrams.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, Jan. 15, 1863.

John Agnew, Vice President, in the chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Donations to the Library were received from the Royal Geographical Society and the Society of Arts, London; the Literary and Philosophical Society, Liverpool; and the Cornwall Polytechnic Society, Falmouth, England; the Oesterreichischen Ingenieur-Vereines, and the K. K. Geologischen Reichsanstalt, Vienna, Austria; the Hon. Secretary of the U. S. Treasury; the U. S. Naval Observatory, and F.

Emmerick, Esq., Washington, D. C.; and from John May, Esq., Prof. John F. Frazer, and Orrin Blodgett, Esq., Philadelphia.

Donations to the Cabinet of Minerals from J. Jenkinson, Esq., Bethlehem, Pennsylvania, through S. Powel, Esq.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement for December, 1862, and his annual statement for the year 1862, were read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (6) were proposed, and the candidates (9) proposed at the last meeting were duly elected.

The Tellers of the Annual Election for Officers, Managers, and Auditors for the ensuing year, reported the result, when the President declared the following gentlemen duly elected:

John C. Cresson, President.

John Agnew, Matthias W. Baldwin, } Vice Presidents.

Isaac B. Garrigues, Recording Secretary.

Frederick Fraley, Corresponding Secretary.

John F. Frazer, Treasurer.

MANAGERS.

Samuel V. Merrick,	Thomas J. Weygandt,	William A. Drown,
Thomas Fletcher,	George Erety,	Coleman Sellers,
Edwin Greble,	Evans Rogers,	William Weightman,
Thomas S. Stewart,	Robert Cornelius,	James S. Whitney,
Alan Wood,	James H. Bryson,	William C. Allison,
John E. Addicks,	Washington Jones,	B. Henry Bartol,
Isaac S. Williams,	William Harris,	Jacob Naylor,
George W. Conarroe,	Joseph Hutchinson,	Elisha Tracy.

AUDITORS.

Samuel Mason, James H. Cresson,
William Biddle.

At a meeting of the Board of Managers, held January 28th, 1863, the following officers were elected for the ensuing year:

William Harris, Chairman.

Isaac S. Williams, William A. Drown, } Curators.

Mr. Howson exhibited to the meeting a large number of locks, not, as he said, because there was anything essentially new in most of those exhibited, but in order to show the great number of devices which had been produced in order to make locks that would answer for either right or left-handed doors.

Mr. H. also exhibited an improved burner for coal oil lamps, invented by Emil Tritten. The wick tube is so isolated that although it is firmly attached to the burner, the heat from the flame cannot be

conveyed to the reservoir so as to vaporize and thus waste the oil. An extremely simple and ingenious burner for coal oil lamps, the invention of W. O. B. Merril, of this city, was also exhibited.

B. F. Joslyn's improved revolving pistol for metallic cartridge, was exhibited by Mr. H. The cylinder of the pistol, on withdrawing the centre pin, may be pushed to one side without entirely detaching it from the frame. The advantage of this is that the pistol may be loaded and the spent cases removed without any liability of losing the cylinder by detaching it. The centre pin passes through a key so connected to the front of the frame that it may also be turned to the side, and the pin pushed back through the openings in the cylinder, thereby forcing out the cases of the discharged cartridges.

A belt fastener, invented by Messrs. Leibrich and Uitting, of this city, was exhibited. Two eccentric rollers, the surface of which are so formed as to present a series of longitudinal ribs having sharp edges, are connected together at the ends by metal plates, in which the journals of the rollers turn. When the surfaces of the rollers are farthest apart, the ends of the strap or belt may be passed upwards between them. On attempting to withdraw the strap, however, the rollers are turned, and the surfaces brought nearer together, securing between them the ends of the belt, which are prevented from slipping out by the sharp edges, or ribs, on the rollers, which hold the ends together with a grip increasing with the force applied to withdraw the ends of the strap.

A combined rule, square, and level, was exhibited by Mr. Howson. The frame of the rule is of metal, filled with vulcanized rubber, which forms in the present instance the body of the instrument, although other substances may be used. By means of a strip of metal, jointed, and contained within the rule, and a spirit-level in a recess in the edge of the same, a number of operations, each heretofore requiring a separate instrument, may be performed.

G. F. Witsel's patent combined washing machine and clothes-wringer was exhibited. In a triangular reservoir vibrates a similarly-shaped dasher, which is so constructed as to form a receptacle for the clothes, which, as the dasher is vibrated, are cleaned by the water which passes through openings in the sides of the dasher and through the interstices of the clothes. The journals of two rubber-covered rollers turn in the opposite sides of the reservoir, and are so situated that the clothes may be taken from the dasher and passed directly between the rollers.

Mr. T. J. Weygandt exhibited a thermo-multiplier, an extremely neat and sensitive instrument, made by himself. The chief merit consists in the compactness, the whole of the essential parts occupying a space but little larger than two cubic inches. Mr. W. stated that a fly on the bars would deflect the needle from three to five degrees.

A General Abstract of the Meteorological Observations made at Philadelphia during the year 1862.—By James A. Kirkpatrick, A. M.
Latitude, 39° 57½′ N. Longitude, 75° 10½′ W. from Greenwich. Height of Barometer fount, sixty feet above mean tide in the Delaware River.

1862. Months.	Thermometer.									Barometer reduced to 32° F.								Dew Point.			
			Range.			Means.						Range.		Means.				Means.			
	Maximum.	Minimum.	Monthly.	Mean daily.	Mean daily oscillation.	7 A. M.	2 P. M.	9 P. M.	Average.	Highest.	Lowest.	Monthly.	Mean daily.	7 A. M.	2 P. M.	9 P. M.	Average.	7 A. M.	2 P. M.	9 P. M.	Average.
	°	°	°	°	°	°	°	°	°	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	°	°	°	°
January,	54	10	44	5·04	10·21	29·36	34·47	31·97	31·93	30·408	29·325	1·083	·261	29 942	29·894	29·931	29·922	23·81	25·23	24·49	24·51
February	52	16	36	5·55	10·89	28 36	36·00	31·64	32·00	30·322	29 216	1·106	·225	29·939	29·891	29·922	29·917	23·08	25·57	25·43	24·69
March,	56	22	34	3 95	14 44	34·22	44·21	39·18	39·21	30·173	29 276	·897	·173	29·804	29·747	29·795	29·782	26 76	28 05	29·86	28·22
April,	82	28	54	5·89	17·87	44·57	55·23	48·28	49·36	30·321	29·422	·899	.146	30·025	29·979	29·994	29 999	34·15	34·34	35·95	34·81
May,	85	40	45	5·77	19·81	57·85	70 08	61·32	63 08	30·058	29·518	·540	.124	29·785	29·740	29·760	29·762	44·89	45 03	46·53	45·48
June,	89	47	42	5·34	17·60	64·57	74·72	66·75	68·68	30·146	29·375	·771	.123	29·738	29·706	29·728	29 724	55 94	56·43	57·91	56·76
July,	95½	53	42½	4·23	17·50	71·13	82 06	73·60	75·60	30·156	29·487	·669	·107	29·743	29·724	29·731	29·733	61·70	60·80	63·41	61·97
August,	95	54	41	3·89	16·56	71·47	82·93	75·13	76·51	30·099	29 557	·542	·122	29·829	29·796	29 818	29 814	61·15	59·16	62·38	60 89
September,	87	48	39	4·30	16·22	63·53	76·03	67·55	69·04	30·086	29·398	·688	·128	29·881	29 845	29·876	29 867	55·82	57·31	59·30	57·48
October,	86	35	51	5·48	15·31	52·70	64·29	56·98	57·99	30·201	29·307	·894	·151	29 865	29·825	29 859	29·850	46 31	48·85	48·21	47·79
November,	71	27	44	5·94	13·40	40·67	48·18	43·25	44·03	30 555	29·380	1·175	·159	29 877	22·823	29·870	29·857	34·64	35·95	35·70	35·43
December,	64	8	56	6·46	12·74	32·24	39·76	34·71	35·57	30·495	29·319	1·176	·197	29·932	29·895	29 936	29·921	26·45	27·27	27·55	27·09
Annual means,	95½	8	87½	5·15	15 21	49·22	59 00	52·53	53·58	30 555	29·216	1·339	·160	29·863	29·822	29·852	29·846	41·22	42·00	43·06	42 09
Winter,	64	10	54	5·42	11·89	30·08	37·58	33·16	33 60	30 462	29·216	1·246	·233	29 973	29 926	29·955	29 951	24·60	26 76	26·57	25·98
Spring,	85	22	63	5·20	17·37	45 55	56·51	49·59	50·55	30·321	29 276	1·045	·148	29 871	29·822	29·850	29·848	35·27	35·81	37·44	36·17
Summer,	95½	47	48½	4·16	17·22	69·06	79·90	71·83	73·60	30·156	29·375	·781	·117	29·770	29·742	29 759	29·757	59·60	58·80	61·23	59·87
Autumn,	87	27	60	5·24	14·98	52·30	62·83	55·93	57·02	30·555	29·307	1·248	·146	29 874	29·831	29·868	29·858	45 59	47·37	47·74	46·90
Means for 11 years,	100½	—5½	106	5.57	15·19	49·69	59·96	53·14	54·26	30·704	28·884	1·820	·156	29·890	29·850	29·874	29·871		43·52		

TABLE (*Continued*).—*A General Abstract of the Meteorological Observations made at Philadelphia during the year* 1862.

1862. MONTHS.	Relative Humidity.							Force of Vapor.							Clouds. Sky covered.				Rain or melted snow.		Winds.	
				Means.							Means.				Means.							
	Maximum.	Minimum.	Range.	7 A. M.	2 P. M.	9 P. M.	Average.	Maximum.	Minimum.	Range.	7 A. M.	2 P. M	9 P. M.	Average.	7 A. M.	2 P. M.	9 P. M.	Average.	Amount.	No. of days it fell.	Monthly resultant.	No. of times in 1000.
	Pr. ct.	Pr. ct.	Pr. ct.	Per ct.	Per ct.	Per ct.	Per ct.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Pr. ct.	Pr. ct.	Pr. ct.	Pr. ct.	Inches.	Days	Direct'n from.	
January,	100	32	68	80·0	70·7	75·4	75·4	·275	·051	·224	·134	·145	·142	·140	74·8	73·5	73·9	74·1	4·500	16	N 18° 26′ W	335
February,	100	44	56	80·4	66·6	77·9	75·0	·267	·060	·207	·130	·143	·142	·138	76·1	73·2	61·1	70·1	4·277	15	N 45 0 W	208
March,	95	25	70	74·4	56·2	70·5	67·0	·389	·081	·308	·149	·159	·171	·159	62·3	66·1	65·8	64·7	3·509	11	N 43 7 W	377
April,	94	18	76	67·8	48·5	64·5	60·3	·555	·091	·464	·211	·219	·228	·219	68·7	67·3	49·0	61·6	3·947	11	N 45 0 E	47
May,	93	18	75	64·2	44·9	60·3	56·5	·594	·105	·489	·320	·324	·335	·326	60·0	60·3	41·0	53·7	2·083	9	N 53 37 W	136
June,	94	33	61	74.7	55·5	74·3	68·2	·770	·180	·590	·463	·470	·498	·477	71·7	66·7	50·7	62·9	6·592	15	S 79 23 W	97
July,	97	36	61	72·7	49·7	71·0	64·5	·813	·311	·502	·561	·544	·591	·566	64·2	63·2	50·0	59·1	2·841	10	S 58 24 W	186
August,	87	30	57	70·5	45·6	65·4	60·5	·939	·290	·649	·562	·524	·586	·557	47·4	58·7	37·7	47·9	1·455	7	S 90 0 W	117
September,	97	32	65	77·1	54·0	75·4	68·8	·833	·211	·622	·465	490	·519	491	58·7	49 7	45·3	51·2	6·282	6	N 4 5 E	87
October,	97	33	64	79·5	59·7	73·5	70·9	·695	·133	·562	340	·378	·365	·361	53 9	51·9	49·3	51·7	4·160	11	N 73 30 W	163
November,	100	37	63	79·4	64·5	75·1	73 0	·545	·106	·442	·213	·228	·224	·222	64·0	64·3	63 7	64·0	4 455	15	N 79 0 W	237
December,	92	31	61	78·5	61·5	74·8	71·6	·377	·040	·337	·154	·163	·162	·160	52·6	58·7	42·6	51·2	1·555	8	N 84 24 W	301
Annual means,	100	18	82	74·9	56·4	71·5	67·6	·939	·040	·899	·308	·316	·330	·318	62·9	62·8	52·5	59·4	45·656	134	N 58 40 W	159
Winter,	100	23	77	80·0	66·4	77·3	74·6	·390	·051	·339	·140	·154	·152	·149	70·3	67·5	56·1	64·6	10 793	35	N 47 35 W	274
Spring,	95	18	77	68·8	49·9	65·1	61·3	·594	·081	·513	·227	·234	·245	·235	63 6	64·6	51·9	60·0	9·539	31	N 48 18 W	143
Summer,	97	30	67	72·6	50·3	70·2	64·4	·939	·180	·759	·529	·513	·559	·533	61·1	62 8	46 1	56·7	10 888	32	S 72 58 W	128
Autumn,	100	32	68	78 7	59·4	74·7	70·9	·833	·106	·727	·339	·365	·369	·358	58·8	55·3	52 8	55 6	14·897	32	N 64 56 W	140
Means for 11 years,	100	13	87	76·1	57·5	72 4	68·7	1·059	·013	1·046	·324	·341	·345	·337	59·5	60·0	44·8	54·8	41·936	127	N 74° 29′ W	227

A Comparison of some of the Meteorological Phenomena of DEC., 1862, *with those of* DEC., 1861, *and of the same month for* TWELVE *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 10½′ W. from Greenwich. By JAMES A. KIRKPATRICK, A.M.

	December, 1862.	December, 1861.	December, 12 Years.
Thermometer—Highest—date,	15th.	10th.	2d, 1859.
" " degree,	64·00°	64·00°	71·00°
" Warmest day—Date,	15th.	9th.	2d, 1859.
" " " Mean,	55·00	54·20	62·80
" Lowest, date,	21st.	4th and 26th.	19th, 1856.
" " degree,	8·00	19·00	4·50
" Coldest day—date,	20th.	28th.	18th, 1856.
" " " Mean,	15·83	26 50	11·00
" Mean daily oscillation,	12·74	14 58	12·28
" " " range,	6·46	5·66	6·37
" Means at 7 A. M.,	32·24	32·52	31·77
" " 2 P. M.,	39·76	42 26	39 26
" " 9 P. M.,	34·71	35·88	34·58
" " for the Month,	35·57	36·88	35·20
Barometer—Highest—Inches,	30 495 in.	30·462 in.	30·678 in.
" " date,	20th.	13th.	18th, 1856.
" Greatest mean daily press.,	30·401	30·413	30·611
" " date,	20th.	12th.	18th, 1856.
" Lowest—Inches,	29 319	29·292	28·916
" " date,	16th.	23d.	9th, 1855.
" Least mean daily pressure,	29·507	29·411	29·175
" " date,	16th.	23d.	9th, 1855.
" Mean daily range,	0·197	0·213	0·211
" Means at 7 A. M.,	29·932	30·040	29·959
" " 2 P. M.,	29·895	29·992	29·920
" " 9 P. M.,	29 936	30·012	29·945
" " for the Month,	29·921	30·015	29·941
Force of Vapor—Greatest—Inches,	0·377 in.	0·390 in.	0·551 in.
" " " date,	15th.	9th.	2d, 1859.
" " Least—Inches,	·040	·069	·025
" " " date,	20th.	15th	18th, 1856.
" " Means at 7 A. M.,	·154	·155	·143
" " " 2 P. M.,	.163	·175	·168
" " " 9 P. M.,	·162	·173	·155
" " " for the month,	·160	·168	·155
Relative Humidity—Greatest per cent.,	92· per ct.	95·0 per ct.	100· per ct.
" " " date,	14th.	7th, 18th, 23d.	Often.
" " Least per cent,	31·	23·0	23·0
" " " date,	2d.	15th.	15th, 1861.
" " Means at 7 A. M.,	78·5	79·5	77·4
" " " 2 P. M.,	61·5	61·9	65·8
" " " 9 P. M.,	74·8	78·5	75·5
" " " for the month,	71·6	73·3	72·9
Clouds—Number of Clear days,*	13	13	9·
" " Cloudy days,	18	18	22·
" Means of sky cov'd at 7 A. M.,	52·6 per ct.	60·0 per ct.	63·9 per ct
" " " " 2 P. M.,	58·7	55·8	63 3
" " " " 9 P. M.,	42·6	33·2	46 0
" " " for the month	51·2	73·3	57·7
Rain and melted Snow—Amount	1·555 in.	2·061 in.	3·527 in.
No. of days on which Rain or Snow fell,	8·	4·	9·9
Prevailing Winds,	s84°24′w.·301	s74°3′ w. ·383	s.59°20′w·289

* Less than one-third covered at the hours of observation.